

INCLUDING A
PAGE SECTION ON **GASOHOL**

A primer on the efficient use of
alcohol for food & fuel

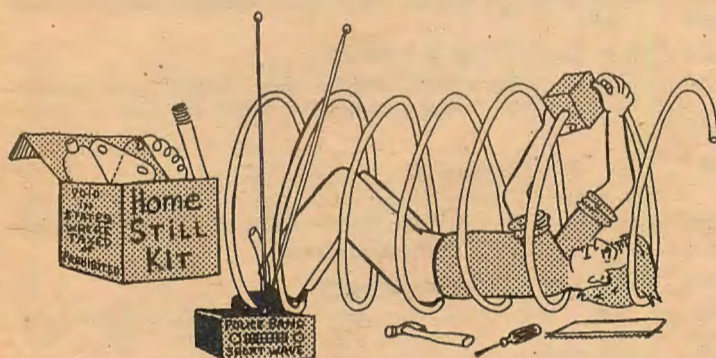
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PREFACE

In just a few short hours it will be within your power to construct your own efficient and economical still. You will be able to build a small still for the production of alcoholic beverages or a larger version for the production of fuel energy. Gasohol is only one of many possible solutions to the fuel shortage explored in this single explosive volume.

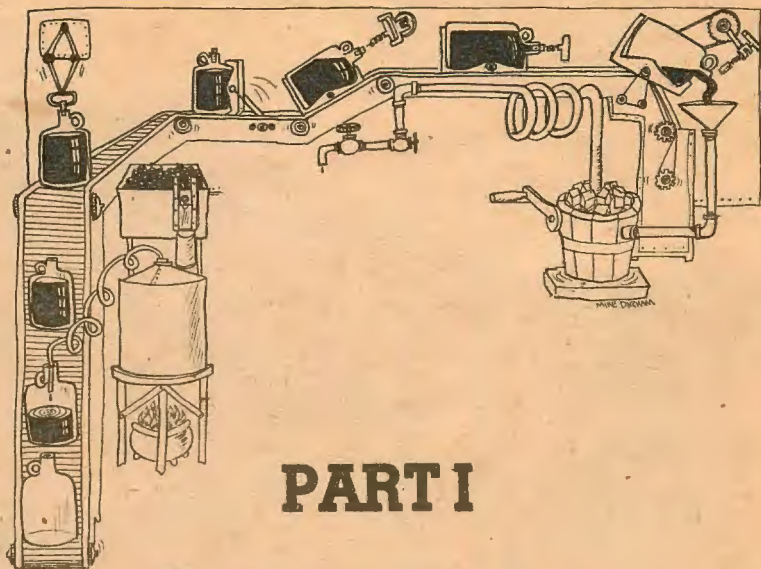
Home wine and beermaking are both legal in the United States, Canada and Great Britain. Home Distillation (operating a still) is not legal. KNOWING how to distill is not illegal, but the DOING is!

However, a variance to the Distillation law can be obtained in the United States for the experimenter who wishes to build his own Still for producing fuel. This variance does not allow the production of beverage alcohol although there is no difference between the two.

Although it is now illegal to distill at home for your own use there is a very good chance that this part of the law will be changed in the future. The same statutes that govern the tax on alcohol also govern the tax on tobacco. Yet it is not illegal to grow and smoke your own tobacco. This is only one of the many inconsistencies in the law that may very well undergo modernization in the future.

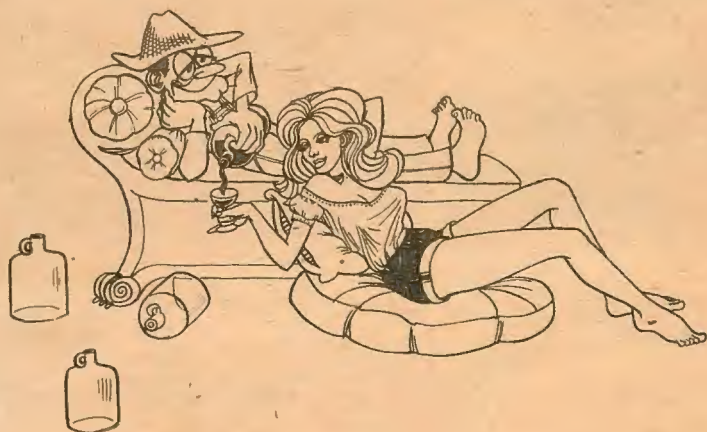
Serious energy shortages have added even greater pressures for the releasing of the legal taboos on the freedom to distill. When such changes are legislated this informational book will then become a valuable textbook to the home distiller.

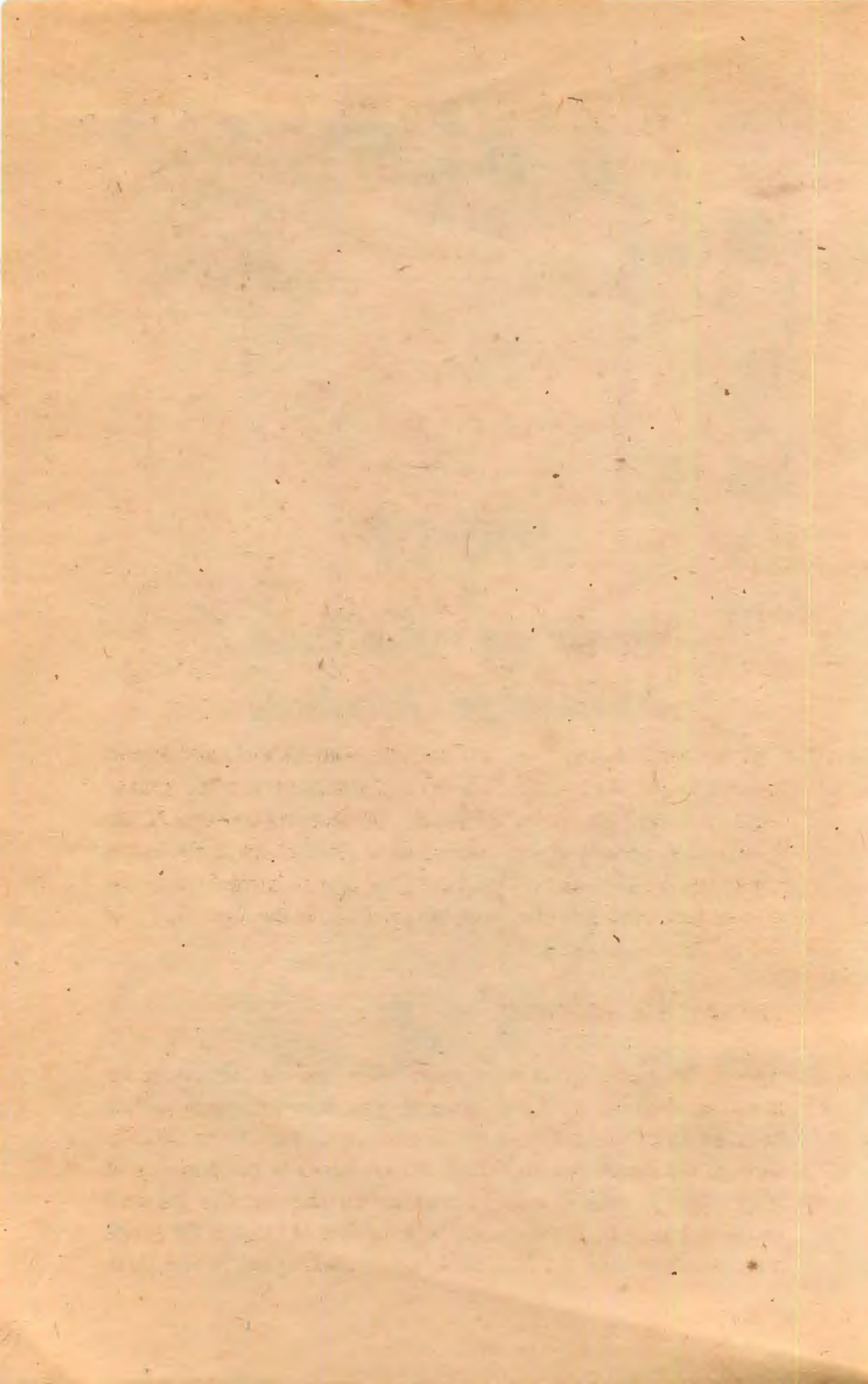
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PART I

How to Produce Beverage Alcohols





CHAPTER 1:

In The Days Of Yore

9

In the days of old

I have been told

When alcohol was uninvented:

They fought and maimed.

And killed and lamed.

And, in general, stayed discontented!



In this book we are going to be talking about Alcohol (also known more correctly as Ethanol). It matters not whether it is in the form of whiskey, wine, beer, vodka, or simply 100 percent pure alcohol. No matter what it is mixed with, brewed in, or distilled out of, the active ingredient in ANY alcoholic drink is, of course, alcohol! And the greater the percentage of alcohol, the more active the ingredient — if not the user — becomes!

PRE-HISTORIC ALCOHOL

Alcoholic drinks, as we know them today, are a rather recent innovation. Alcoholic drinks, in general, have been with us for as far back as written history exists. Alcohol came into being initially through the simple decomposition of food juices in the presence of yeast. This process is called Fermentation and includes the well known products Wine and Beer. For a number of reasons the grape plant was probably the first exploited in making wines and then

followed other sugary fruit juices. Finally, through a two-step process called "malting" and "mashing", beer was probably introduced. The oldest historical records (from 4000 BC or about 6000 years ago) show the presence of both Wine and Beer — as well as the sporting game of Backgammon!

Obviously, the alcoholic beverages produced in those earliest of times did not resemble those of today. Sealed and pressurized containers were very rare. Open crockware was the name of the game. Thus carbonated beverages, such as beer and champagne which require pressurized containers, were not available. Cooling during most of the year was equally unavailable. The beverage relished and fought over would strike modern man as being a cross between sandy mouthwash and much used dishwater. But it did contain Ethyl alcohol, and once past the nose and tongue, it produced the same effect that you and I and the rest of mankind are so familiar with. It is not our purpose at this point to go into the makeup of what is now considered a good wine or beer. This will be dealt with in Chapter 6. Suffice it to say that Fermented alcohol did exist in copious quantities from somewhere way back in mankind's gray and misty beginnings. Its palatability was another matter.

HISTORIC ALCOHOL

By the time that the Greeks and Romans came onto the stage (about 500 BC to 0 BC), alcoholic beverages were still confined to the wines and beers, but the quality was much improved. The liquid was drained off of its lees or dregs and containers with closures were commonly employed for storage. Some preserving herbs were being used at this time and the beverages became quite palatable.

The Greeks, of course, had to have a god for everything. The god of fruitfulness (Dionysus) was given a face-lifting and emerged as the god of the vine and, hence, of wine. Other names for this same god were Bassareus, Sabazius, and Bacchus. The latter name is most often used in modern literature as the god of wine.

The final step - and a very large one indeed — in the evolution of the alcoholic drink was the discovery of **DISTILLATION**. Aristotle (380-320 BC) was familiar with distillation as were several others mentioned in writings of the period preceding the middle ages. In 800 BC the Chinese were distilling Rice Beer to obtain a more powerful drink. In Europe, however, no application of distillation was made to Alcoholic beverages until the Arabians introduced the idea into Italy about 1225 AD. From there the idea slowly spread into Spain, France, and northward into the European countries until it was in popular usage by 1650. Oddly enough, the Arabians do not drink alcohol as it is forbidden in the Moslem religion by the Koran (Moslem Bible).

Early Still



It will do well for us to interrupt our story at this point to briefly explain the difference between **Fermentation** and **Distillation**. In so doing we will come to understand the actual differences, also, between such diverse drinks as Beer, Wine, Brandy, Whiskey, Vodka, etc.

FERMENTATION is the term we use to explain the process that takes place when we add yeast to a sugary solution of fruit, vegetable or grain juices. Yeast are small micro-organisms having properties of both plants and animals but generally classified with the plants. The yeast use the sugar in the liquid for food, and in so doing they expel Ethyl Alcohol and Carbon Dioxide as byproducts. The carbon dioxide is given off as a gas and bubbles up through the liquid. The alcohol stays in solution and produces unusual cerebral effects when ingested by animals. In other words it is a narcotic drug. One must avoid

becoming emotionally traumatized by the description of alcohol as a narcotic drug. Quite simply a narcotic is any agent that has a soporific, or deadening, effect on the brain, or in some pronounced manner alters the mental acuity of the user. Even aspirin can be used as a narcotic.

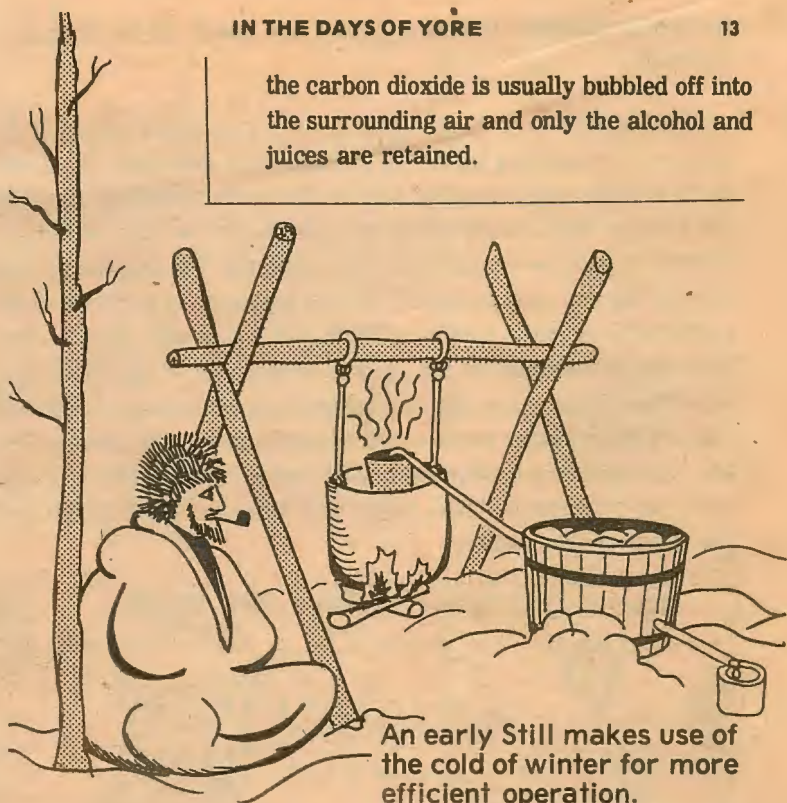
ALCOHOL is the name given to a class of compounds containing many members such as Ethyl alcohol (Ethanol), Methyl alcohol (Methanol), Isopropyl alcohol, etc. Only one of these can be drunk in any quantity without producing lasting ill effects. This one is Ethyl alcohol which is given off as the byproduct of the Fermentation Process.

All Alcohols are poisonous to varying extents. Some only mildly toxic, such as Ethyl & Isopropyl. Some terribly toxic, such as Methyl alcohol. But Isopropyl alcohol is not intoxicating — that is you can get neither drunk nor “high” on it. It does not affect the brain. Methyl alcohol is commonly called wood alcohol since it is easily produced by heating wood (usually logs) in a large closed oven without oxygen. The vapors that are boiled off consist largely of Methyl alcohol. Methyl alcohol was at one time used in automobile radiators to prevent freezing but has largely been replaced by Ethylene Glycol in recent years. Methyl alcohol is deadly poisonous. Isopropyl alcohol is mixed with 30 percent water and sold as Rubbing Alcohol (70 percent Isopropyl). Alcohol will be discussed more fully in Chapter 3.

For the time being we need to remember that Ethyl alcohol is the only one that can be drunk safely — in moderate quantities of course. In Part I of this book the single word Alcohol, by itself, will always mean Ethyl alcohol unless it is further qualified.

YEAST are tiny microscopic plants that thrive in sugary solutions such as fruit juices. A microscope of 500 to 1000 magnifications is needed to examine them. They sub-divide, or bud, to multiply. Under the right conditions they expel Carbon Dioxide and Alcohol. For making bread the yeast are added to the dough so that the slight fermentation which takes place can introduce Carbon Dioxide bubbles in the bread and, hence, lighten it. For making fermented beverages,

the carbon dioxide is usually bubbled off into the surrounding air and only the alcohol and juices are retained.



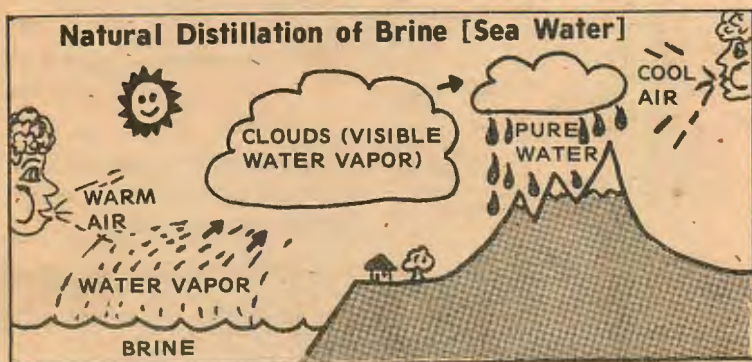
An early Still makes use of the cold of winter for more efficient operation.

Unfortunately the yeast plants cannot go on making alcohol indefinitely. The yeast stagnates when the alcohol percentage in the solution approaches about 18 percent by volume (depending on the yeast variety and techniques employed). The increasing concentration of alcohol renders the yeast cell inoperative and it becomes dormant whether sugar is present or not.

Now we come to the heart of the matter. All drinkable alcohol is produced initially by the **FERMENTATION** process. This is a rather large statement. It includes such things as brandy, vodka, scotch, gin, beer, wine, vermouth and anything else you may wish to mention such as liqueurs, cordials, ad nauseam. The question immediately arises as to how whiskey, say, or gin, either of which contains appreciably more than the upper limit of about 18 percent alcohol, can be obtained from fermentation. Strong liquors (concentrated alcohols) are made from

fermented alcoholic beverages (wines and beers) by the process of Distillation.

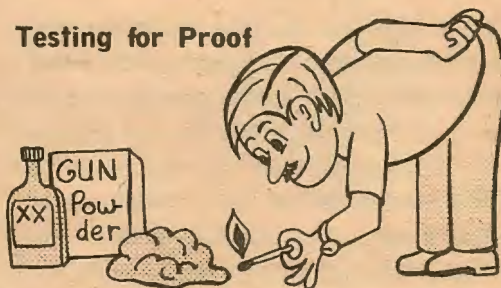
DISTILLATION, or rectification as it is sometimes called, is the process of separating mixtures or compounds into their constituent parts by a process of heating, evaporating and condensing. It can be put simpler than that by citing an example or two. Sea water is a mixture of pure water, salt and many minerals. The dissolved solids, such as salt and most minerals, will not evaporate or vaporize to any appreciable extent in normal sunlight, but water will. Thus the heat from the sun shining on the oceans, evaporates or vaporizes huge quantities of pure water, leaving behind most of the solids mentioned. These clouds of vapor travel overland and come into contact with cool air which causes them to condense (or return to the liquid state) and the result is a rainfall of pure water. The water was **DISTILLED** from sea water in this manner.



Most liquids with differing boiling points can also be separated in the same manner. As the temperature is raised in such a solution one of the liquids will begin evaporating before the other and the resulting vapor, if condensed, will contain more of the liquid with the lowest boiling point. Such a separation will not be nearly so perfect as the first case cited where solids are dissolved in a liquid (sea water) and where separation is almost perfect or very efficient to say the least. In the case of several liquids mixed together, the efficiency of the separation will depend more on how close or how far the boiling points

of the liquids are from each other, what their relative concentrations are and the nature of the liquids involved. But never-the-less, in general, a separation can be effected and the process is known as **DISTILLATION**.

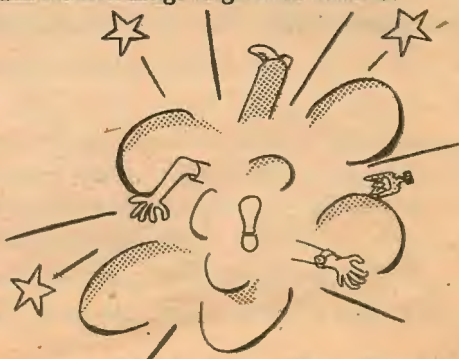
Testing for Proof



Distilled beverages are normally measured in **PROOF** values which in the United States are simply twice the percentage by volume figures. In other words, a beverage that

contains 10 percent alcohol by volume is also 20 proof in the U.S.A. This is not true in Great Britain or Canada, however, and a comparison set of proof tables is given in Table C (Chapter 12) between all of the systems commonly employed. There is no rational reason for employing these different systems of percentages and proofs. They simply evolved over the years. The term proof is said to originate from a method that was used of adding alcoholic liquor to gunpowder and then trying to ignite the powder to establish whether the liquor was "proof" or not. Since alcohol is quite flammable the gunpowder would readily burn if the liquor poured on it did not contain too much water. Obviously, such a system would be a rather crude measurement. The term proof is still maintained in modern usage as given in Table C.

We can now return to the chronological setting of our earlier discussion. At our point of departure from the thread of our story, we had just introduced the Arabs to the Italians (about 1225 AD) and the Arabs had immediately acquainted the Italians with



... Must be Another Way!!

DISTILLATION: It took until 1650 to spread all over Europe. Since this is a period of over 400 years, it is apparent that the new methodology did not travel at anywhere near the speed of light. But it wasn't bad speed for the times considering that Europe was in the renaissance during this period and quite disorganized to say the least.

One of the first products of the new distilling techniques was Brandy, or Cognac as it is sometimes called. The reason for this is that the first **STILLS** made (from the word **diSTILLation**) were inefficient. They produced a higher percentage alcoholic drink than was possible with fermentation alone, but did not anywhere near approach the efficiency of later stills. A first run through these Stills did little better than double the percentage of alcohol. Thus, instead of a 15 percent wine, the **STILL** would present a 30 percent brandy. By increasing the efficiency of their designs and/or by running the Brandy back through their Stills again they were able to increase this yield to a 40 percent to 50 percent Brandy. This is more like we know Brandy today.

Brandy was **THE** drink from about 1700 to 1800. Brandy is now distilled out in a single run through a still to 40 percent to 55 percent alcohol and stored in Oak barrels for about 5 years before bottling and selling. Initially, it was "aged" only accidentally when an especially good year resulted in more than could be drunk or when barrels might be overlooked for a few years in a dark and little used Wine Cellar. When it was noticed that some of this older stock was much improved in flavor or taste (the alcoholic percentage stays the same or decreases slightly) the concept of Aging was born.

Brandy fits into many of the popular scenes that were described for us by writers of that era. A true and touching story concerns one of the greatest mathematicians of all time. He was only 21 years of age and was doomed to fight a duel which he could not win. The night before the duel, he sat down with a beaker of Brandy and committed to paper all that he knew and understood from his researches. The next day he was killed in the duel, and his night's work resulted in the creation of a new branch of mathematics. His name was Evariste Galois and he

was killed at Paris, France, on May 31, 1832. So much for Brandy and dueling.

During the 1800's the supply and quality of Beverage Alcohol increased by leaps and bounds. And the demand increased at least as fast. Alcohol, in many areas such as Kentucky and Tennessee, became a medium of exchange as valuable as money. The more transportable the more valuable it became. Whiskey was born because of the expense of shipping grain from midwest graineries to eastern markets. The grain (corn, wheat, oats, rye, rice, etc.) was converted to a mash, fermented, distilled and shipped for a much greater net profit than otherwise obtainable.

For a variety of reasons, alcohol soon became a very taxable item. It was in high demand and it took equipment and know-how to manufacture in distilled form. In 1792, the first tax was passed on active Stills in the U.S. Then, as now, the accent for taxation fell on the distilled product and not the fermented. Because of the ease of fermenting and concealment it is not difficult to understand why the line was drawn at distillation. The first tax laws allowed stills under 400 gallons to either pay an annual tax or, if they did not operate continuously, a monthly tax, based on the schedule of operation. From 1815 to 1862, was a tranquil period. During this time there were no taxes on any alcoholic beverages, distilled or otherwise. The Civil War, and its needs for revenue, re-instituted the liquor tax which has not been off the books since.

The tax in 1862 was 20 cents per gallon of proof liquor (100 proof or 50 percent alcohol). A mere pittance. As with all taxes, there seemed but one direction to go with the passage of time — UP!! In 1864 it was reset at 60 cents per proof gallon. Except for some brief excursions during the latter years of the Civil War, the tax stayed relatively constant until 1900, by which time it had risen to \$1.10 per gallon; \$3.20 in 1917; then down to \$2.00 in 1934 after the repeal of the 18th amendment (prohibition). By 1951, this had risen to \$10.50.

At the present time it costs about \$150.00 to pay for the wholesale costs on a 55 gallon barrel of 200 proof Ethyl Alcohol - but the Federal taxes you must pay before you can call it your own amount to about \$1,000.00!! This, of course, is before any state or local taxes are added. Alcohol and Tobacco are the only two items that have had a continuous excise tax since the Civil War.

ALCOHOLIC EXCESSES

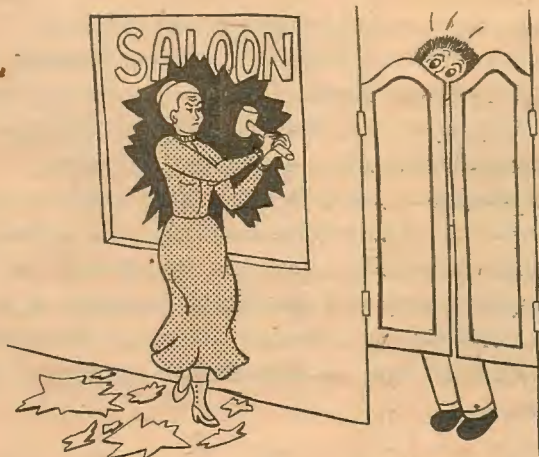
The 1800's brought forth a drastic change in the public's attitudes toward alcoholic beverages. The relaxed and easy-going early 1800's gave way to the very intemperate Temperance Societies in the late 1800's. By 1900 an ugly mood was evident throughout the United States. The temperance movements started in Maine with the passage of one of the first sweeping prohibitory laws in the nation. Before long, however, the real strength of the movement shifted to the midwest and the south where it remains to this day. It is easy now for us to look back and regard those in the forefront of such movements as being narrow and bigoted. It is easy but it would be unjustified.

By the latter half of 1800, the industrial sectors of the world were plagued with alcoholism on an alarming scale. The pathetic tales of poorly dressed little waifs shivering in the cold trying to get their fathers to come home from a saloon were a little overdrawn. But Alcoholism was on the increase as industrialization spread. Even fishermen out on the high seas were not immune. In the North Sea, between England and the European Continent the seas were filled with floating saloons. Special legislation was needed to control the situation.

The United States in 1900 was emerging as the most powerful nation in the world. But as the nation grew ever larger and more complex so also did its internal problems.

CHAPTER 2:

Post Yore Days



TEMPERANCE MOVEMENTS

Chapter 1 dealt briefly with the subject of potable (drinkable) alcohol as it was known to mankind up through about 1900. By this time the casual approach to the drinking of alcohol was commencing to be replaced by the critical and even condemnatory. Definite and different points of view were emerging. Each individual, of course, maintained a view that was the result of the sum total of his experience to that time.

These personal experiences were colored by the occupation of the individual citizen. The lawyer, though he might enjoy drinking, was brought into daily contact with the consequences of over-drinking. The tax collector saw it as merely another commodity used to support the necessary activities of the State. The religiously inclined, in spite of the manifold biblical references to wine, were also brought into daily contact with its misuses. Social groups could not ignore the impact of excessive drinking on their own local life styles. Such groups as the W.C.T.U. (Women's Christian Temperance Movement) and the

Salvation Army bridged the gap between social and religious concerns and took an activist part in either discouraging drinking or picking up the pieces from the consequences of its misuse.

Pendulums have a way of swinging in both directions – but never simultaneously. In spite of efforts by Presidents Roosevelt, Taft and Wilson in the first two decades of 1900, the handwriting was on the wall. The complexion of succeeding sessions of Congress became increasingly prohibitory where alcohol was concerned.

It is characteristic of the American political system to over-react and to legislate against the symptoms while ignoring the causes. It did not act uncharacteristically in this crisis. The Supreme Court fell into line and approved some very questionable legislation as being constitutional (Webb-Kenyon Interstate Commerce Amendment Bill vetoed by President Taft, the Jones-Randall amendment, the Reed amendment, etc.)

Local states and cities were voting themselves dry in attempts to solve the problem on their own. Their plight was understandable and while the solutions they proposed were hardly laudable, their options were strictly limited. The Federal Government had the only power available that could provide the national sense of purpose needed. Instead of assuming that those who trafficked in liquor or that those who drank it in excess were simply "bad", some questions needed to be asked concerning the quality or desirability of our social structures as they had evolved to that time. What caused so many of our fellow citizens and toilers to prefer stupefaction to cooperation??

PROHIBITION

The 18th Amendment was passed by the necessary two thirds vote in the Senate on August 1, 1917 by a vote of 65 to 20. On December 17, 1917, it passed the House by a vote of 228 to 128. The necessary two thirds state approval was obtained on January 16, 1919. One year later, on January 16, 1920, National Prohibition commenced in the United

States. The Volstead Act was passed by Congress on October 28, 1919, to provide for drastic enforcement. It was vetoed by President Wilson but was passed over his veto. From January 16, 1920 to December 5, 1933, it was not legal to manufacture, sell, transport, import or export beverage liquor in the United States of America. The "Noble Experiment" had begun!

THE 40 YEAR CYCLE



1920 - 1932
Drinking or
Possessing Alcohol

1960 - 1975
Smoking or
Possessing Marijuana

2000 - ????
Who Knows?

During Prohibition, the repressive legislation passed and judicial actions taken remind one very much of the recent drug problem. The situations are so clearly similar that it causes pause for wondering if our collective intelligence as a nation hasn't peaked out. Cars were searched for alcohol and if a passenger had alcohol on him, even if unbeknownst to the driver, the car and all personal possessions in it were confiscated and sold by the State. As an isolated example, a lawyer named S.S. Holt was shot and killed on his way home from arguing a case in the United States District Court in Raleigh, North Carolina on June 1, 1925. The officer shooting him dead stated that Holt stopped his car for a moment along the roadside and thus he, the officer, thought Mr. Holt was carrying liquor in the car. This turned out to be totally unfounded. Mr. Holt was killed without warning and in the presence of the Chief of Police.

Paid informers were hired to infiltrate groups and encourage them to buy alcohol illegally so that the "culprits" could be arrested by the State Authorities. Constitutional liberties were set aside if the question of alcohol arose — and the community approved.



Such petty and demeaning acts on the part of the Federal and State governments invited the contempt of the governed. And the invitation was readily accepted. The pocket whiskey flask came into vogue as a safe way to carry whiskey on ones person. Meanwhile the unresolved national problems which precipitated the crisis in the first place were simply becoming worse and we entered into the worst depression in our history.

REPEAL

Finally, in 1932, the simmering revolt against the 18th Amendment and the Volstead Act entered into the presidential campaign pitting Roosevelt against Hoover. The 21st Amendment repealed the 18th Amendment and was ratified on December 5, 1933. National Prohibition was dead.

We were rescued temporarily from our profound lack of a cogent national purpose by the self-preservation instincts during the 1930's and 40's. War engulfed the world and allowed us to look the other way for another two decades. When we looked back, we were astonished to find that our problems had not gone away . . .

AFTER REPEAL

Although the 21st Amendment repealed Prohibition, by no means did it mean the end of government intervention and control of liquor. The State governments now assume the task of regulating the liquor traffic but the Federal Government keeps for itself many prime controlling functions. Licensing and inspecting of plants or firms

having anything to do with the manufacture, importation or distillation of alcohol is a Federal prerogative. Federal regulations lay out the entire foundation and framework within which the liquor industry is compelled to operate.

Most of the Federal Government's regulations are set forth to insure that tax payments cannot be easily avoided. The state regulations are more often colored by local prejudices and mores but are also laid out in such a manner as to insure that the proper tax revenues are collected. State taxes and controls vary widely and are usually moderate in scope and tone. It is worth noting, however, that the Federal statutes are not moderate. You cannot obtain a license for distilling for your own use and you cannot obtain a license to distill in a home or anything close to or resembling one. You cannot build a Still even for purifying water, unless you register it with the Federal government.

While this all may sound oppressive, and undoubtedly is, these laws can and may be modified in future years. However, if you suggest such a modification to your local representative or senator, you should be prepared to answer one question: If this tax source is eliminated, where are the several billion dollars in revenue that liquor taxes produce each year going to come from??



OTHER COUNTRIES

In Canada the Scott Act is used to determine whether an area will be wet or dry. The British, in general, have a more relaxed legal attitude

toward liquor than does the United States. The Canadian laws operate about midway between those of their U.S. neighbors and the British Commonwealth. The United States is the only western country to have experimented with National Prohibition. Saudi Arabia enforces a National Prohibition policy because the majority of its people are of the Islam religion (Moslems) which, itself, prohibits the drinking of alcoholic beverages.

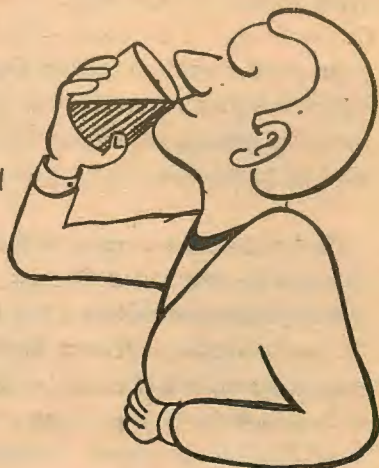
Thus, while the average citizen in the United States might imagine that all of the old "Pot Still" methods now in existence came from the hills of Kentucky or Arkansas, it is just as likely that at least part of the methodology originated in the frozen tundra of a northern Canadian Province or on the hot sands of the Rub' al-Khali desert in the southern Arabian peninsula.

And so here we are in the Post Yore Days. And in spite of all the troubles we have there are at least two positive things that can be said about our present situation: it certainly is an interesting time to be alive and thank God we got our alcohol back!!

CHAPTER 3:

Fundamentals of Alcohol

*Ethanol. Methanol. which is best
Finding out requires a test.
You go first, at my behest.
Hope you enjoy your permanent rest!*



FIRST FUNDAMENTALS

This is the only "technical" chapter in the book. If you have only a little difficulty with this chapter then struggle through as it will help your understanding immensely. If you find it extremely difficult then skim through the difficult portions and read the rest. Be assured that you can still understand completely the rest of this book even without this chapter!

Heretofore we have been following the usual practice in the everyday world of grossly misusing the word alcohol. Alcohol is really the family name for a whole group of compounds with widely varying characteristics. Ethyl alcohol, or grain alcohol, is properly called **Ethanol**. We shall use **Ethanol** primarily from this point forward when discussing Ethyl alcohol. This chapter delves into some of the interesting facts about all the alcohols with the emphasis on **Ethanol**, of course. There are many things about the alcohols you might find surprising. The more you know about this fascinating narcotic the better you will be able to use it to your advantage throughout your life.

CHEMISTRY OF ALCOHOL

The word Chemistry alarms some people almost as much as the word Sex bothers others. Neither word will bother you in this book as we are not going to say enough about the former to make you unhappy nor enough about the latter to make you happy.

The two great subdivisions of chemistry are Organic and Inorganic. Although the distinctions no longer mean much of anything, they were devised when chemists were first trying to put some order into what we must all agree is a very disordered world. Organic compounds were originally thought to be concerned solely with life processes. All of these contain Carbon whose chemical symbol is "C". Carbon is found in all life processes - whether animal or plant. Thus all compounds with carbon in them fell into the broad class of Organic compounds. Coal and Oil are two of the most important members of this broad group of Organic Compounds. If the organic compound contains Carbon and Hydrogen (symbol for Hydrogen is H) together, it is called a Hydrocarbon. Coal, Oil and Natural Gas are all Hydrocarbons.

A single molecule of Carbon is denoted by C alone. Two molecules by C_2 ; three by C_3 etc. This system of numbering the molecules of any element is applied to all the elements.

The Hydrocarbons are found to be composed of almost all conceivable combinations of Carbon and Hydrogen. Some Hydrocarbons contain one Carbon atom (C) and four Hydrogen atoms (H_4). This is written as CH_4 . Others are C_5H_8 , and even huge groups such as $C_{100}H_{202}$. In order to group these more logically, chemists arrange these molecules according to their size. Out of all the possible combinations, several groupings of order are made. One of the first discovered by our friends, the chemists, is a group whose symbols and names are, in ascending order:

TABLE I
ALKANE series of
the ALIPHATIC hydrocarbons

CH ₄	Methane
C ₂ H ₆	Ethane
C ₃ H ₈	Propane
C ₄ H ₁₀	Butane
C ₅ H ₁₂	Pentane
etc.	etc.

As you have probably guessed the list could go on almost forever as the molecules get larger and larger. As you might have also guessed, the first listed are the lightest. The first few are light gases, then heavy gases, then liquids, then thick liquids (such as tar) and finally solids. The names of most of these compounds are probably familiar. Methane is the explosive gas found in many coal mines. Propane and Butane are sold under great pressure, in tanks, for home and farm usage.

Chemists have a way of never letting well enough alone. Having discovered these rather unusual and never-ending chains of molecules, it was further found that by making slight changes in the structural formulas other non-ending groups of compounds could be accurately described. For instance the first member is Methane, CH₄. By substituting what is known as a Hydroxyl group (one atom of Oxygen and one of Hydrogen — OH) for one of the Hydrogen atoms in Methane a new stable compound is formed whose formula is CH₃OH. By making the same substitution into the entire Alkane series above, we get a brand new series:

TABLE II

Aliphatic ALCOHOLS

CH_3OH	Methanol (Methyl Alcohol)
$\text{C}_2\text{H}_5\text{OH}$	Ethanol (Ethyl Alcohol)
$\text{C}_3\text{H}_7\text{OH}$	Propanol (Isopropyl Alcohol)
etc.	etc.

Although this process of substituting and renaming could and does go on for some time, we can recognize our destination and this is where we get off. The first member is wood alcohol, the second is beverage alcohol, the third is rubbing alcohol. Only the second is of real interest to us.

Notice that there are two systems of naming the alcohols. Such a double system of naming is one of the unusual features of organic chemistry. Both are correct. However, in recent years it has become more common to use the so-called systematic names such as Methanol, Ethanol, etc. This is because many people, in their rush to oblivion, failed utterly to pay heed to anything but the name alcohol. As a consequence some Methyl Alcohol has been drunk mistakenly for Ethyl Alcohol. Methanol is a deadly poison . . . oblivion comes ahead of schedule!!

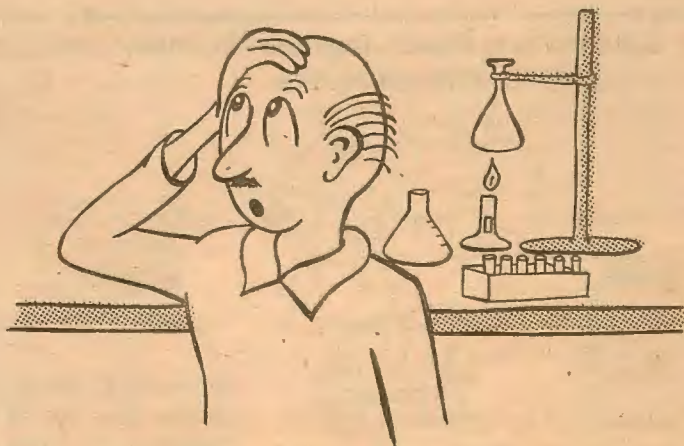
As a point of interest, Isopropyl, or rubbing alcohol, is very little more toxic than Ethanol, but unfortunately for the beverage hound, it is not intoxicating either. As mentioned before, its primary usage is as an antiseptic and in a 70 percent solution with water, as a liniment to be rubbed on sore muscles (rubbing alcohol).

PROPERTIES OF ETHANOL (ETHYL ALCOHOL)

Table II shows the first few member of the Aliphatic Alcohols. You would expect that they have some similar properties or what would be

the use in grouping them together? On the other hand, you would expect some dissimilar properties or what would be the use of giving them different names? So far as similarities are concerned, most have a pleasant odor and they enter into similar reactions with other chemicals. In other respects they are loners. As we have learned, Methanol is very toxic, Ethanol slightly toxic and Isopropyl only slightly more toxic than Ethanol. Only Ethanol is both non-toxic and intoxicating — which is a study in contradictions!! Two other alcohols worthy of mention are Ethylene Glycol (used as anti-freeze and Glycerol, or glycerine.

Pure Ethanol boils at a temperature of 172.9 degrees F. or 78.3 degrees C. (at sea level). In this text we are not going to be much concerned about pure Ethanol. In our experience, the Ethanol will be mixed with a mass of other materials, some liquid, some starches, and some compounds which defy accurate description. Thus, it is more useful for us to determine how a mixture of ethanol and water behaves as we will encounter this situation by far the oftenest. Wine and Beer are both very close to being a simple mixture of water and Ethanol.



Let me see . . . today I guess I will discover Adiabatic Triangulated Morphology!

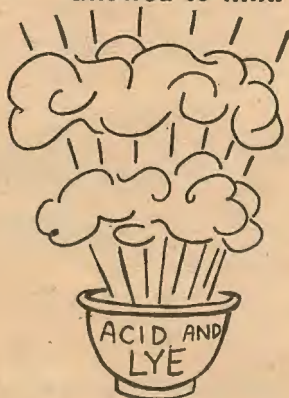
WATER AND ETHANOL

When two different liquids are mixed together, all sorts of things can happen. One liquid can float on top of the other such as with oil and water. An immediate explosion can occur such as with a strong acid and base mixture. The combination can take up heat (endothermic) or it can give off heat (exothermic). The two can remain independent of each other totally (a mixture) or they can exist semi-independently where they share the common spaces and remain everywhere homogenous (a solution) or they can chemically combine to form brand new compounds. Ethanol and water are in the middle class. They mix uniformly in all proportions and a small amount of heat is given off when they are so mixed. The volume of the solution is also a little less than the sum of their original volumes. 52 volumes of alcohol mixed with 48 volumes of water, combine to make 96 volumes of solution instead of the anticipated sum of 100. They are said to be Miscible in each other, meaning that they can mix in all proportions without one or the other settling out or becoming saturated. But they do not, in general, form a chemical bond. Share and share alike is their motto.

Two Liquids can React Together in many ways if allowed to mix.



Oil floats
on water



Acid & Lye
explode violently



Ethanol & Water
share the space
together & both
spread uniformly
throughout
the solution

Because of this loose sharing arrangement Ethanol cannot be re-separated from water without a little effort. For instance, it cannot simply be poured off the top as an oil and water mixture could. On the other hand, it does not require the enormous effort it would take to break a chemical bond. For the present it is enough to know that through the process of Distillation we can effect a very good separation.

DISTILLATION

From an engineering point of view, distillation can become a complex thing. But in theory and in general practice, it is nothing more nor less than boiling a mixture of liquids in the hope that one or the other will boil off first. If one does it can be collected as steam, cooled to condense it back to a liquid and, hence, separated. It actually works. And, as can be expected, it works better with some solutions and poorer with others. In the next few paragraphs we will discuss in some detail the actions that take place when we boil two different liquids together. It will make your understanding of the following chapter easier and, perhaps, you may even find it interesting.

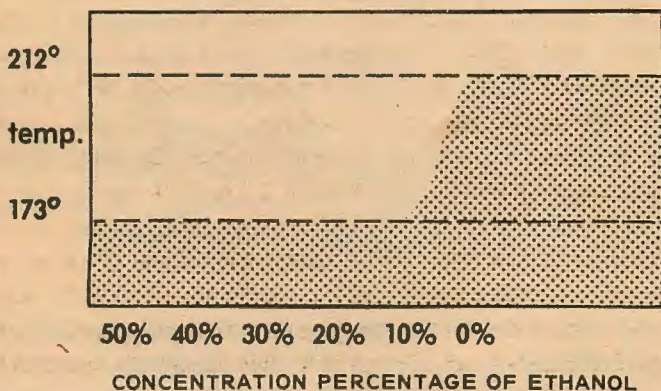
If it is desired to separate two totally miscible liquids, that are in solution together, it can be done by boiling distillation if and only if they do not form an Azeotrope. An Azeotrope is a mixture of substances all of which boil at the same temperature (constant boiling temperature). The worst that we can say about azeotropes is that they are difficult to spell or pronounce. Any pure substance, such as water, boils at a constant temperature until the last drop is gone. Most liquids in their pure state follow this same rule and it is safe to say that there are few substances, indeed, with exactly the same boiling point. So it would seem that we are spending valuable time and paper on a rather rare phenomena.

A great many solutions with different boiling points do form azeotropes and Ethanol and water is one of these. Fortunately for us

there is only one critical concentration of Ethanol and water which forms an azeotrope and even more fortunately this concentration is almost pure Ethanol with very little water. The azeotropic concentration for Ethanol and water is 97.2 percent Ethanol (this would be 194.4 proof!). Below this concentration, say for instance a 50-50 mixture, the solution boils at or very close to the temperature of Ethanol (about 173 degrees F.) until all of the Ethanol is boiled off, at which time there is a sharp rise in the boiling point to that of water (212 degrees). Table III shows this.

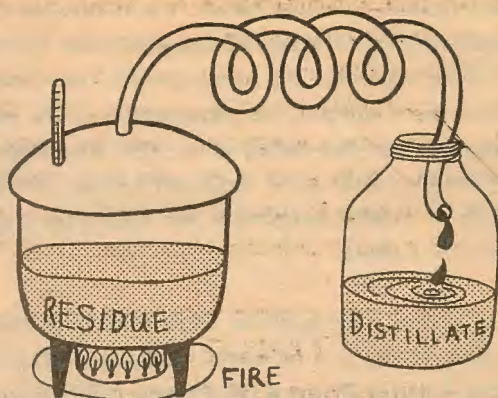
TABLE III

Variation of Boiling Point with Concentration of Ethanol in Water



Because both liquids have some vapor pressure, at all times there will always be a little water going into vapor (steam) along with the Ethanol. But until the point is reached where less than 10 percent of the Ethanol exists, most of the vapor is Ethanol. The substance being heated or boiled in a distillation is called the Residue and the boiled off portion is the Distillate.

After a first distillation the Distillate should be at least double its initial percentage. The percentage alcohol in the Distillate is going to depend on its percentage in the Residue before distillation began, on



the skill of the operator, and on the efficiency of the still. Starting with a typical mash of, perhaps, 10 percent alcohol, a first run on a simple still might yield a Distillate of about 30 percent alcohol. To increase this percentage higher, the obvious procedure would be to run the distillate through the still again . . and again . . . and again, until the desired percentage is reached. When this is done, the distillate **Does Not** get closer and closer to 100 percent Ethanol. It approaches 97.2 percent Ethanol. This is because at 97.2 percent the solution becomes constant boiling (azeotropic) and the amount of Ethanol in the vapor is exactly 97.2 percent which leaves the residue the same and it keeps right on boiling at the same old temperature. This temperature, by the way, is 78.2 degrees C. or 172 degrees F. It is just a trifle less than the boiling point of pure Ethanol alone (less than a degree).

For the curious, this unusual feature is a result of the deviation of the mixture from a so-called "ideal" solution. In an ideal solution, each molecule intermixes freely and totally with its foreign neighbors but in no wise becomes associated with them in any chemical bonds. The result is a perfectly homogenous solution with each component of the solution being evenly distributed throughout the solution in direct proportion to its proportion in the total solution. Some time back we mentioned that when alcohol and water are mixed together, a slight amount of heat is generated (the solution is exothermic). If this were a detective novel we would remind you that you had received the vital clue to the solution (no pun intended).

The heat release indicates that on the atomic level there is some hanky panky going on. Some Ethanol molecules are playing around with the water molecules and forming some loose bonds. These loose associations are disturbing the homogeneity of the solution — don't they always — and the result is a slight alteration of the vapor pressure (boiling point) of the combined liquids. This, in turn, causes the solution to become azeotropic just before the point at which it would be pure Ethanol.

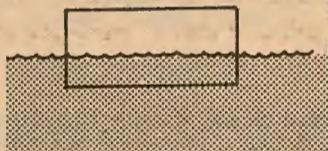
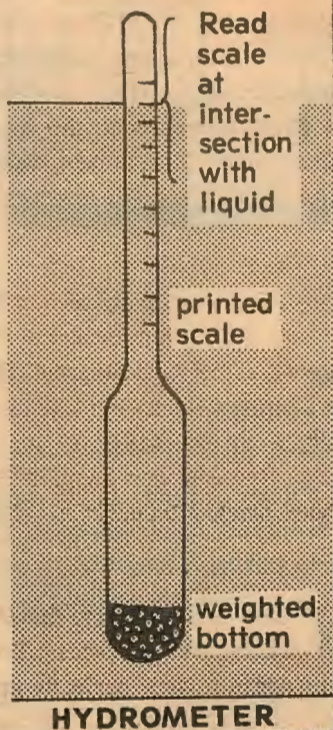
This has several consequences. Pure Ethanol is rarely sold on the open market. If you buy an uncut (undiluted) grain alcohol at the liquor store, it will be 190 proof (95 percent) rather than 200 proof. This is below the azeotropic concentration. There are other ways to achieve 100 percent Ethanol, but it is hardly worth the bother as far as beverage alcohol is concerned. The extra 5 percent would appreciably increase the cost and nobody, but nobody, drinks Ethanol in anywhere near that concentration anyhow.

Anyone operating a conventional still must be made aware that it is futile to try to achieve a greater concentration than 97.2 percent. To do so such things as Entrainers must be added to your perfectly good alcohol. In this case the process is every bit as formidable as the word. Who wants to add such things as benzene to their expensive alcohol just to get another few percentage points of purity? Have you ever tasted benzene??

Cut and Uncut are two terms you will run across occasionally. They indicate respectively, Dilute and Undiluted. The Diluent used is nearly always water or juices. A diluent is an inactive additive used to dilute (cut).

MEASUREMENT OF ETHANOL

The amount of alcohol in the Distillate can be easily measured with a P&T (Proof & Tralle or simply Proof) Hydrometer.

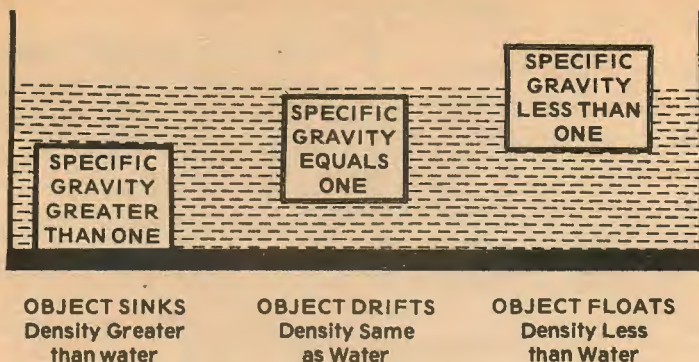


Hydrometer principal: The submerged part of the block displaces an amount of water that weighs exactly the same as the entire block. Discovered by Archimedes.

A Hydrometer, as used in alcoholic measurements, is a long, thin, hollow and sealed tube, usually glass. Archimedes was the first one to have discovered the principle of the hydrometer which is that any object floated in a liquid floats at such a point that the liquid displaced by the submerged part of the object is exactly equal to the weight of the whole object.

Wood floats on water because it weighs less. For the space it occupies than an equivalent amount of water. If we place a small weight on a floating block of wood, it sinks into the water enough more to compensate for the extra weight. The pressure pushing down on the water is exactly balanced by the pressure of the water upward on the object. We call this concept of weight per space occupied the **Density** of the object or medium. If the **Density** of an object is greater than that of water (such as a rock or iron bar), it sinks.

Because water is so common in the world pure water is used as the reference medium in measuring density and is given a value of one (1). Density, when compared to water in this manner is also referred to as **Specific Gravity**. Thus, if something has a density of 8, such as iron, this



DENSITY (weight per given volume)

means that it is 8 times as dense or 8 times as heavy as the same amount of water. Common sand has a density of 2.3 and therefore is 2.3 times as heavy as water (or 230 percent). Oak has a density of .71 and therefore is only .71 (or 71 percent) as heavy as water. Ethanol has a density of .79 or is 79 percent as heavy as water.

Since Ethanol is lighter than water, but doesn't really float in water, the obvious result of mixing Ethanol and water is to alter its density. Thus, a solution of Ethanol and water will have a density between .79 (pure Ethanol) and 1.0 (pure water).

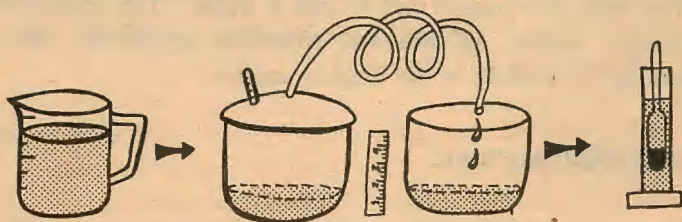
A P&T hydrometer has scales to read off the Specific Gravity or Density in units of either Proof (twice the percent of alcohol by volume) or Tralle (percentage of alcohol by volume).

It is not nearly so easy to measure the alcoholic percentage of fermented juices. These contain much dissolved foreign material such as starches, sugars, microscopic bits and pieces of fruit or grain particles, etc. This solid material in suspension alters the gravity reading in an unpredictable fashion as the solid content of fruits or grains are never exactly, or even approximately, the same from fruit to fruit. This need not concern us unduly. Only rarely, if ever, will we want to

know the original alcoholic content of the fermented mash or juice. It will either have fermented completely or not and there are easy ways to tell one way or the other. And after fermented mash has run through the still at least once, it can be measured accurately with a P&T Hydrometer from that point onward.

One method of measuring the alcoholic content of a freshly fermented juice or mash is to remove a liquid sample of a pint or so and distill out **Exactly** half of this sample in a small still. This distillate will contain all of the alcohol, will be free from contaminants, for the most part, and can be measured with a P&T Hydrometer. Take half of the reading obtained in this manner to find the alcoholic content of the batch from which the sample was removed. For instance, if the hydrometer shows a proof of 40 in the distillate then the original sample, before distilling must have had an alcoholic content of half this amount, or a proof of 20 (10 percent alcohol by volume). Hydrometers^{*} with different scales are needed to measure wines and beers.

One Method of Determining the Original Alcoholic Percentage of A Mash



Remove a small portion of the mash (pint or quart, for instance)

Distill out exactly half of this sample

Check this distillate with a P&T Hydrometer. The alcoholic percentage of the original mash is half of this value.

^{*}Consult the book **MAKING WINE BEER & MERRY** by Howard & Gibat for a full discussion on hydrometer measurements of wine and beer.

Another type of Ethanol measuring device is a Vinometer. This is a thin glass tube, smaller than a hydrometer, and which uses the change in surface tension of an Ethanol and water solution to yield its measurement. It has few things to recommend it, but it does take very little Ethanol to perform this measurement (a few drops) and it can be done quickly. It has been reported in some literature to be inaccurate while other sources suggest that if the tubing is wet down first with some diluted Ethanol and then cleared out completely, it performs very well. Vinometers are also used to determine alcohol content of dry, or nearly dry, wines.



Vinometer

PRODUCTION & THE USES OF ETHANOL

Fermentation is the best known source for Ethanol and throughout most of the world it is the only source. In the United States, however, it accounts for only about 20 to 25 percent of the total output. The rest is made synthetically from Ethylene, a hydrocarbon. The synthetic alcohol so produced is used industrially for the most part. The only liquid

solvent with more usages than alcohol is water!! The production of varnishes, shellac, plastics and smokeless gunpowder are all dependent on alcohols in one form or another.

DENATURED ALCOHOL

There are many industrial uses for Ethanol as has been pointed out. Because of the tax rate, its cost would make it too expensive to use. The government does not want to lose valuable tax dollars by giving workers in a plant access to cheap Ethanol. There are several alternatives. If the manufacturer must have pure Ethanol, such as for an additive to food colorings, then the government requires that the manufacturer keep strict and exact accounting of each and every drop that comes into his possession. This can be a tremendous bother and is

costly to the manufacturer, but in some cases is unavoidable.

In most cases, the alcohol does not need to be pure so long as it does not contain certain harmful products to the manufacturing process for which it is needed. For use in these cases, the government keeps a list of 56 different and specialized additives to add to the Ethanol to ruin it for beverage purposes. This process is called **Denaturing**, and these types of denaturants are termed **SD** for **Special Denaturants**. One such of these is **Acetaldehyde**.

In other cases, the type of additive has a much wider latitude. In these cases, the government keeps two **CD** formulas (for **Completely Denatured**) on hand. **Methyl alcohol** and **Benzene** are used in these formulas as fouling agents.

These fouling agents are both deadly poisons. Thus the Federal Government is put in the uncomfortable position of intentionally poisoning Ethanol and thereby inadvertently causing a few deaths each year. It is much akin to a householder keeping a shotgun handy for burglars even though it is understood that this same action by all householders is going to result in a few burglars being shot (and possibly killed) each year.

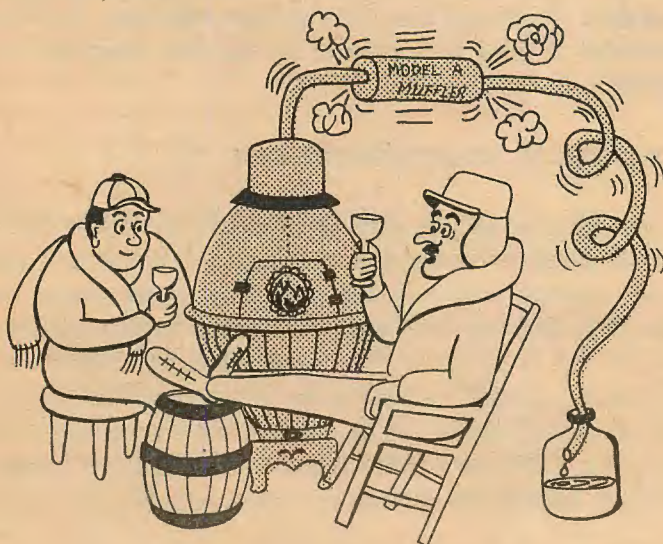
PHYSIOLOGICAL ASPECTS OF ETHANOL

In this section we will say a few words about you and your Ethanol and what effects you have on each other as you share the same body. Ethanol is used by the body as a fuel in the same manner as sugar. It is ultimately broken down into **Carbon Dioxide** and **water**. However, its absorption rate is very slow. You can absorb about a **tablespoon** of pure Ethanol per hour, but this varies widely according to individual disposition, energy output, and size. In other words if you are working very hard and are over weight you can drink more alcohol, without feeling any harmful effects, than an underweight, lethargic person.

Ethanol causes the outside skin temperature to rise and the internal organ temperature to drop. This is a very bad combination if you are

going to be exposed to generally cold conditions. It is the opposite of what would be desirable. You can freeze to death in a hurry. Ethanol is toxic and acts as a mild poison. When you drink it faster than it can be assimilated it builds up in the bloodstream and depresses the central nervous system. Thus it is a depressant or "downer" as they are sometimes called. The difference in concentration levels that your body can tolerate is about 4 to 1. That is at levels of about 1 Part Per Thousand (PPT or .1 percent) you are barely conscious of its presence. At 4 PPT you would be in an alcoholic coma which could easily be fatal. At points in-between you are in-between.

Ethanol is present in your body at all times. It is a natural by-product of some bodily functions. Its natural level is, however, quite low. It is interesting to note that because of its toxicity to living organisms, the alcohols in general are used as antiseptics. Isopropyl alcohol is commonly employed for this. As the concentration is increased the antiseptic properties improve markedly until a con-



'bout time we changed the muffler Henry, it's backfiring again!

centration of 70 percent is reached after which its antiseptic powers decrease. This is a rather unexpected departure and this is why the common Isopropyl alcohol sold as Rubbing Alcohol is commonly marketed in a 70 percent by volume mixture.

Ethanol is primarily metabolized in the liver. This is why the misuse of Ethanol so often results in Cirrhosis of the liver. Ethanol is high in calories and is easily absorbed from the digestive tract into the bloodstream. But, unlike carbohydrates and fats, it cannot be readily stored in the tissues, it can scarcely be disposed of through the kidneys or lungs, and cannot be oxidized by normal body tissues. Thus this high energy substance enters the body and cannot be simply discarded – as many substances can – but must be burned up and this “burning” can only be accomplished in the liver. The liver, alone, contains the necessary enzymes for breaking the alcohol down into carbon dioxide and water.

The liver of the average healthy person has no difficulty in metabolizing moderate amounts of Ethanol. Excessive drinking in spurts can cause the liver to generate and store fats as a result of this high metabolism. These fats, however, are a reversible condition and would normally be washed away in the bloodstream when the high alcoholic ingestion ceased. Continued excessive drinking – as in the case of an alcoholic – leads first to Hepatitis (death of some liver cells) and then cirrhosis (fibrous scars in the interconnecting tissues of the liver which interfere with the liver's ability to function).

The lesson here is Not that Ethanol is harmful. Like most other things we eat or drink the human body appears to have no difficulty in adapting itself to a moderate intake of Ethanol. Too much fat in our diets causes atherosclerosis and results in heart attacks. Too much alcohol harms the liver. The lesson is that moderation in all things is much to be desired.

FLASH POINTS OF ETHANOL

Determining the flash point of a combustible liquid can be

dangerous so you would be ill-advised to try it. But the procedure is quite simple. The liquid to be tested is heated until the temperature is reached at which the surface of the liquid ignites when a match is held close to it. The temperature at which the surface can be ignited is the **Flash Point**. To find the flash points of oils, they are usually immersed in sand (for safety's sake) and then heated gradually while a thermometer reading is taken and a flame held close to the surface of the hot sand. In the case of gasoline no heat is needed. It is already above the flash point at room temperature. So is pure Ethanol whose flash point is 51 degrees F. But the flash point for 90 proof ethanol, (Whiskey or Vodka straight from the bottle) is 78 degrees F.

All of this is to say that precautions must be taken around any still and its distillate. Especially when the liquids are hot and highly concentrated. Common sense precautions need to be observed but one need not be paranoid about it. A fire extinguisher should always be handy and everybody should know how to use it. No smoking should be allowed on still premises. That sort of thing!

CHAPTER 4:

Basic Mash & Methods

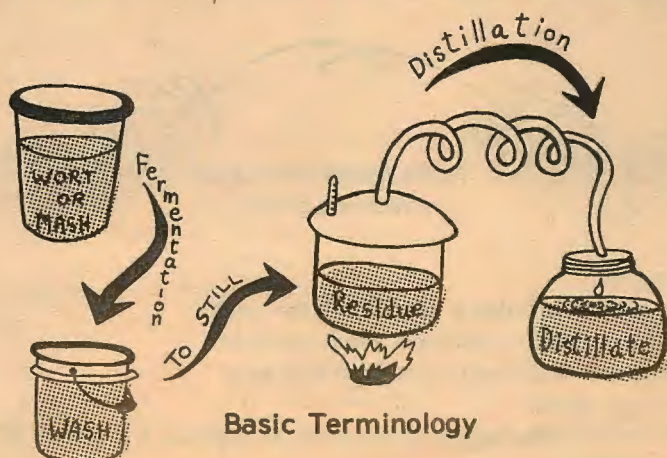
ETHANOL PRODUCTION

This chapter deals with a most important aspect of distillation – producing the ethanol to be distilled! Through time and experience many good ways have evolved.

The process of fermentation has already been discussed. A little more is written on the subject in Chapter 6. Almost all of our beverage alcohol begins as a fermentation, but fermentation alone will produce a drink no stronger than about 16 percent Ethanol (32 proof). In this chapter we shall learn a number of good ways to get that 32 proof, or thereabouts, beverage. In the next we shall learn how to boost this proof as much as we might choose. By distillation, of course!

MASH RECIPES

Even though you may be using any number of basic juices for fermenting your initial product for distillation, we shall term these either

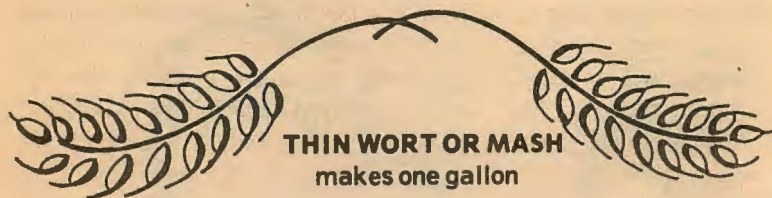


Basic Terminology

Wort (pronounced wurt as in hurt) or **Mash**. It is still called **Wort** or **Mash** during fermentation. **Mash** is the popular usage, but **Wort** is more correct. After the **Wort** has fermented out fully we shall call it the **Wash**. Once it has been passed through a Still we shall call the portion left in the Still the **Residue** and the portion that passed through the still the **Distillate**.

Washes can be produced from an infinite variety of different substances. The primary requirement is simply sugar in a dilute solution of water with a few nutrients (fertilizer, if you will), and vitamins. The nutrients needed are the usual nutrients for plant and animal life such as potassium, phosphates and a few trace elements. The B Vitamins, such as Thiamin and Riboflavin are helpful to furnish a healthy, vigorous ferment. For a **Thin Wort**, as we shall call it, follow this recipe:

Note: unless otherwise indicated, all **Wort** recipes will be for one gallon of **Wort**. To make larger batches, simply multiply all of the ingredients (except for the yeast) by the number of gallons desired, and follow the same general instructions. In the case of the yeast its amount should only be increased slightly. For instance for a 5 gallon batch, use about a Tablespoon of yeast. The amount of yeast is not critical.



2 lbs. sugar

1 level teaspoon bakers yeast or wine yeast.

1 teaspoon vitamin-enriched yeast nutrient

1 Tablespoon of lemon juice or citric acid

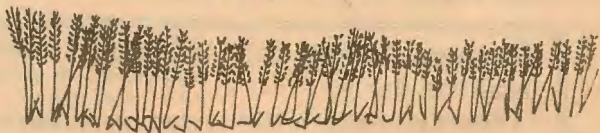
1 Campden tablet

Enough tepid (luke warm 75 degrees-90 degrees F.) water to make 1 gallon.

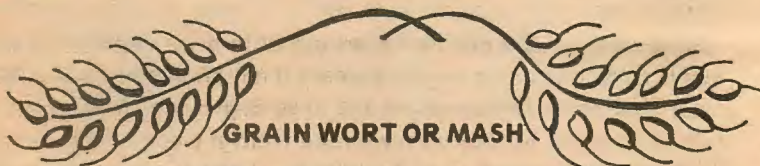
Yeast nutrient and Campden tablets can be purchased economically from a Home Winemaking Supplies shop. Try to obtain vitamin enriched nutrient if possible. Dissolve the sugar, nutrient and lemon juice in enough water to make a total of 1 gallon. Stir extremely well and make a lot of bubbles in it. Oxygen from the air helps the yeast start to grow. Add the yeast and cover with a loose fitting lid or cloth. Do NOT clamp down with a tight lid or you will be sorry! Much carbon dioxide gas is released as the fermentation proceeds and if you tightly cap it, the gas will generate enough pressure to burst your container and spread it evenly all over the room.

Keep the fermenting container in a warm room (75 to 80 degrees F.). It should ferment vigorously within a few days and continue to ferment for one to two weeks. The fermentation will be visible as a bubbling, frothing, unsavory looking activity on top of the liquid. This is good. Don't knock it just because it doesn't fit your idea of an elegant mixture. It doesn't fit ours either, but it is necessary. Cheese, butter, yogurt, etc. all go through a similar process.

After a week or two, all activity should pretty much subside. Taste a tiny bit of the Wash (it won't hurt you). If it is sour, or at least unsweet, then the ferment is over and you are ready to distill. If it is sweet, then it is not through fermenting and will need to set a while longer. You can go ahead and distill a Wash even if it does taste a little sweet, but it will not yield you quite as much alcohol as a totally fermented Wort. If it is only a little sweet, and you are not distilling any great amount, the difference probably isn't worth worrying about. Your yield will be very nearly the same. However, if you have a large batch, say a few hundred gallons, that slight sweetness is going to cost you a fair amount of pure alcohol, maybe a few gallons or even more. Thus for small batches, you can afford to be a little inefficient, but not for large ones.



The above Wort is fine if you have lots of sugar available. Most people do not. Especially farmers. Thus, the usual Wort or Mash you have heard so much about doesn't resemble that described above. It is made from grain because grain is the commonest and cheapest raw material around. It also makes the smelliest Wort.



There are several basic steps in making a good grain wort. Each is important. It may seem complex at first -- and it is -- but once learned and mastered, it is an extremely efficient Ethanol-producing system. The steps involved are **Malting**, **Gristing**, **Mashing**, **Brewing**, and **Fermenting**, in that order.

1. Malting

Basically, malting converts the non-fermentable starch in a grain to fermentable sugar. Any grain such as corn, wheat, barley, rice, etc. or any combination of grains may be used. The grain used must be for seeding, because it must sprout before it is roasted. Here are a few hints on what to look for in a good malting grain:

- a) It should have even grain size.
- b) It should be fully ripe.
- c) It should have "good condition"
(i.e. sweet and dry)
- d) It should be internally floury. . .an indication of low nitrogen content.
- e) It should **Not Be** chemically treated as many commercially sold seed grains are.

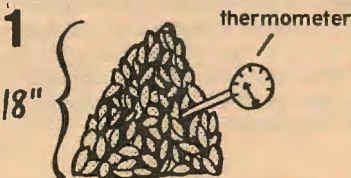
Choosing A Good Malting Barley

A BUSHEL SHOULD WEIGH
ABOUT 56 POUNDS

MOISTURE - 15 percent
PROTEIN - 10 percent
FAT - 2 percent
STARCH - 50 percent
OTHER - 23 percent

Soak the grain for 24 hours, change the water, and soak for another 24 hours. Skim off and discard anything that floats (husks, broken grains, contaminants, etc. The grain may be soaked a week without harm so it is best to leave it a little long. The grain grows best between 63 and 86 degrees F. It must not get too cold. When adding more water, make sure the water is cool but not cold.

Next, spread the drained seed out onto a wet surface (wet towels or clean burlap bags do nicely if not allowed to dry out). Keep it at room temperature (63 to 86 degrees F.) and wait - until it sprouts. Sprouting may take from a week to ten days. Wait until the sprout is $\frac{1}{4}$ inch long. If the layer of grain is more than one inch deep, or the grain is kept covered, it must be turned twice a day to ensure good ventilation.



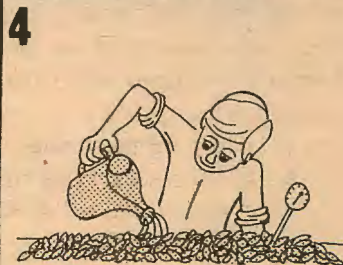
Place soaked grain in heaps one to two feet high (18 inches is recommended). Leave for 12 to 24 hours. Internal temperature should not exceed 60 degrees F.



After 3 or 4 days, very thin hair rootlets should be apparent.



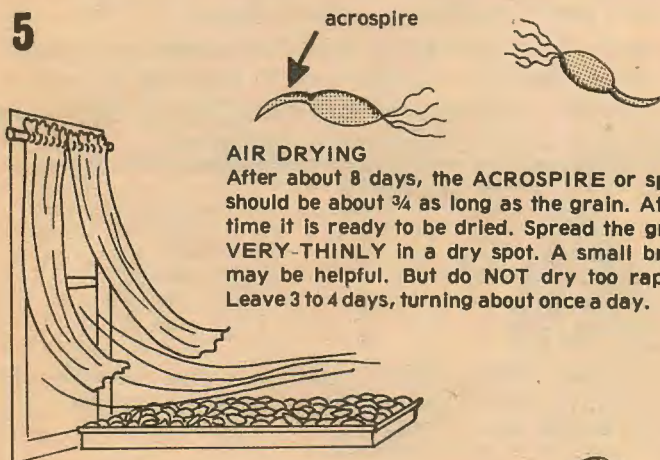
Spread grain evenly in a thin pile (in cool weather up to 2" deep, in warm weather much less). Stir grain carefully every 5 or 6 hours to prevent heating up.



Once rootlets appear, start sprinkling lightly. Turn grain after sprinkling to spread water. **USE WATER SPARINGLY.** Use just enough to keep grain from drying out. Turn grain over after sprinkling and once or twice a day. Turn carefully to keep from tearing up rootlets. Keep temperature between 50 and 70 degrees F.

Next, the now-germinated seed must be dried out, preferably in a low temperature oven. When drying the malt, moderate the heat first. Do not let the temperature exceed 122 degrees F. until the malt appears to be dried. This will take a number of hours. Then raise the temperature slightly in 10 degrees steps but do not exceed 140 degrees F. Keep the temperature constant during each step for an hour or so. The grain is now **Malted**.

5



AIR DRYING

After about 8 days, the ACROSPIRE or sprout should be about $\frac{3}{4}$ as long as the grain. At this time it is ready to be dried. Spread the grains **VERY-THINLY** in a dry spot. A small breeze may be helpful. But do **NOT** dry too rapidly. Leave 3 to 4 days, turning about once a day.

6

KILN OR OVEN DRYING (4 day duration)

Turn malt once or twice each day. For **PALE MALT**, use this guide:

Day 1 - 90 to 100 degrees F.

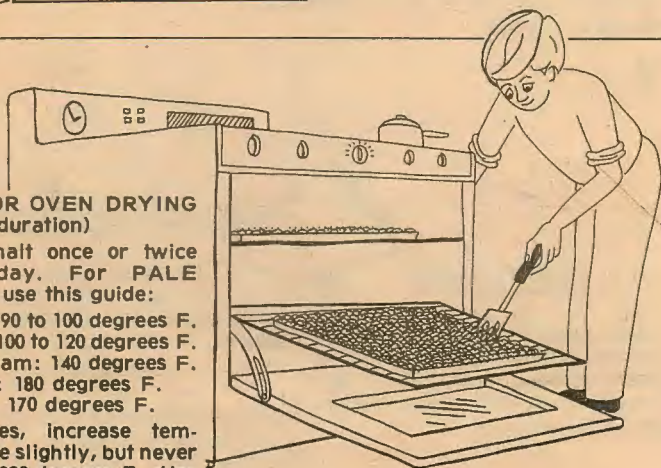
Day 2 - 100 to 120 degrees F.

Day 3 - am: 140 degrees F.

pm: 180 degrees F.

Day 4 - 170 degrees F.

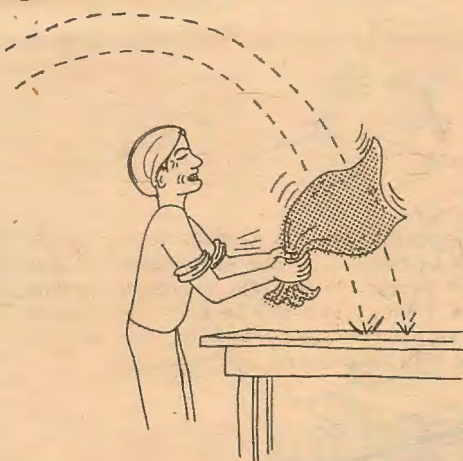
For ales, increase temperature slightly, but never exceed 220 degrees F. Use of a mechanical turner will give best results.



2. Gristing

Now the grain is ready to be cracked or crushed to be made into grist. Cracking may be done in a coarse-grind grinder, a coffee grinder, or by using a rolling pin.

7



CLEANING & DE--SPROUTING

Rootlets are removed prior to gristing by placing the grain in a sack (such as a pillow case) and banging it repeatedly against some hard surface.

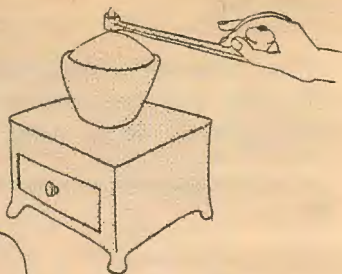
8

After knocking the rootlets loose, place the grain in a sieve and toss grains into the air to turn it over. The rootlets and chaff will fall through the holes in the sieve (best not done indoors).



GRISTING

Malt can be used new or stored for aging. Some brewers prefer to age the malt first for at least a few months. The malt is next gristed or broken up. Old coffee grinders with a coarse setting are excellent for this. A rolling pin can also be used, but is more work. If other grains are to be used in the wort, these are gristed along with the malt.



9



3. Mashing & Brewing

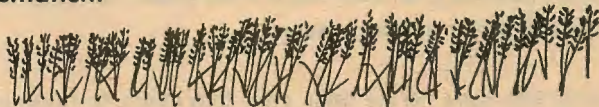
The next step is called mashing, and is the one where the rest of the Starch is converted to Sugar. Yeast can ferment only simple sugars -- not starches. This conversion to sugar can be done in a number of ways. The simplest is boiling it for 45 minutes to an hour, then straining out the grain. A much more efficient method, which allows the maximum extraction, is a longer process. Put 2 pounds of grist (cracked or crushed malt) in a bucket of water with a glass immersion heater. Wrap the bucket in a blanket and let sit overnight or for 8 hours. 130 to 150 degrees Fahrenheit allows for maximum extraction. Strain liquid into a boiler and add enough water to make 3 to 4 gallons. Boil one hour. Test to see if starch has been converted completely by removing a teaspoon of wort and adding a little iodine to it. (Caution: Be Sure To Throw

The Mixture Of Malt And Iodine Away As Iodine Is Poisonous)! If the mixture turns blue, it has not yet all converted and may need further boiling.

When all the starch is converted (no color change -- or very little color change -- when iodine added), the mixture is ready to use. The grain is now Mashed.

4. Fermenting

After the wort or mash has cooled, to below 90 degrees F., a tablespoon or two of yeast per gallon of Wort is added. This yeast will cause the wort to ferment. It is during this fermentation process that the sugar in the grain turns to Ethanol. Proper fermentation takes about 5 to 10 days. During this period, The temperature must be kept between 70 and 90 degrees F. Skim off the foam during the first few days of fermentation.



POPULAR STRONG DRINKS

WHISKEY is produced from a grain wort or mash using the general method outlined in the last section. For different types of Whiskeys the formulae and procedures are changed somewhat. We will list the changes in this section for the most popular Whiskey types.

For Bourbon Whiskey use 6 parts Corn, 2 parts Rye and 2 parts Barley. However, you malt Only the Barley. Then you make grist of All the grains (grind them together). Mix them and proceed into your mashing and brewing in the normal way. In the next section we will explain why it is not necessary to malt all of the constituents.

Sour Mash Whiskey follows the normal recipe, but requires that you add the dregs from a previous batch to your new wort in place of the

yeast, and let the fermentation proceed naturally from the dormant yeast cells in these dregs. You do not add any new yeast to your Sour Mash. Of course, you cannot make Sour Mash Whiskey until you have made at least one batch of Sweet Whiskey since you will not have the dregs until then. The name stems from the fact that, normally, the old dregs taste and smell a little sour because they are slightly acid.

Sweet Mash Whiskey, as its name implies, uses new yeast

For Pure Rye Whiskey, only Rye is malted, gristed and mashed. Most recipes use about 9 parts of Rye grain, however, and add 1 part Malted Barley (the Rye is Not malted in this case. . .It is ground to a grist with the Barley Malt and mashed in the usual way).

Irish Whiskey uses 10 parts of malted barley, 7 parts of fresh barley grain, and 1 part each of fresh oats, rye and wheat grains. Thus half of the grist is malted grain and half is fresh grain. The grist is mashed and brewed in the normal manner.

Scotch Whiskeys derive their very thin claim to fame primarily because their malt is dried by smoking it with Peat smoke and they use local water in their washes. If you wish to believe that this somehow imparts them with expensive unique characteristics you may, of course, do so. The distillers of some of these products spend much money trying to create this illusion.

For Rum use the Thin Wort recipe on page 44, but substitute molasses for the sugar. You will have to use a Wine Hydrometer to adjust the Specific Gravity of the Wort to about 1.060 to 1.070. Then ferment in the normal way to obtain the Wash.

Vodka is little more than a mixture of Ethanol and water. Use the thin wort recipe on page 44 and distill it out to a very high proof. This removes almost all of the Congenerics (minute quantities of chemical byproducts that enter greatly into the aging process, and impart much of the flavor and "character" to the beverage) and leaves very nearly

a pure alcohol (180 proof or so). Then cut this down with pure water to the proof level desired using Chart A in Chapter 12.

Gins are heavily rectified (remember that word?) as is Vodka. The usual wort consists of 16 parts corn grain, 3 parts Malt, and 1 part Rye grain. However, just before the last rectification a little flavoring, such as Juniper Berry is added to the Wash which replaces the natural Congenerics with the artificial side products of the additive. Other additives are Licorice, Angelica, Almonds, and sugar (2 to 5 percent). The resulting very Ethanolic drink (120 proof no more) is then cut down to the desired proof level. Dry Gin is distilled out to a higher proof level before cutting it back down with water. Hence the name "Dry".

Brandy is usually the result of only one or at most two simple distillations. Also the wash used is a "new" wine (not aged) of one type or another. For true Brandy, grapes are used. This grape wine is then distilled and the distillate is simply called Brandy. For all other fruits and vegetables, a new wine of the appropriate type is used. For instance, Apricot Wine is used to make Apricot Brandy. Carrot Wine to make Carrot Whiskey, etc. For anything other than Brandy made from grapes the wine type is appended to the name as illustrated above.

AGING

Almost all liquors are aged, with the possible exceptions of Vodkas and Gins. Previously used Oak barrels are considered the best if kept sweet and clean. If none are available charred oak casks are used. These barrels allow the liquor to "breathe" through its pores. The minute amounts of air thus introduced alter the congeners (Esters and Aldehydes primarily) which undergo very slow but very definite chemical transformations during the "aging" process. Oak barrels supply small amounts of tannin. The charcoaled barrel sides provide some filtering action and gravity induces some settling. The Ethanol content actually decreases a little. Three or four years is probably the

average aging time for most liquors. Some even do well up to 10 or 20 years. Fine Napoleon Brandies over 75 years old are — as one source exclaims in despair — “a bit of romantic nonsense”. Liquor does not automatically get better with age. After a certain point it gets worse. . . and worse! Any liquor, wine or beer over 25 years old should be suspect.

MALTING & MASHING EXPLAINED

A while back we quickly went through the process of making a wort or mash from grains. If we did our job correctly, you should have understood the fermenting and the gristing. If you did your job correctly, you should be wondering about the malting and mashing. What is all this hocus-pocus about sprouting the grains, drying them and then boiling it all to a pulp? You don't really have to understand the process to make it work but if something goes wrong it is easier to correct if you understand the process.

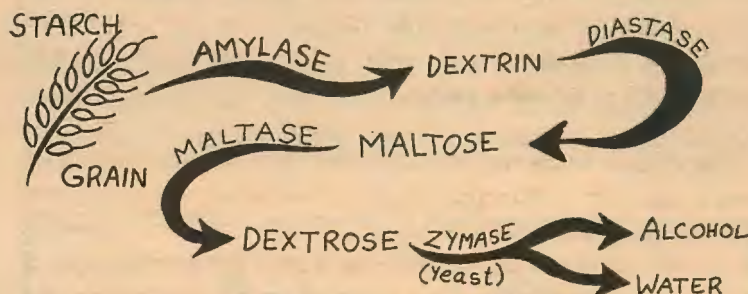
Enzymes are really the name of the game from here on in. They occur everywhere in life processes. You have them in your mouth, your stomach and your intestines to name just a few places. They are not completely understood even by scientists. They are proteins like gelatine or steak. They do not enter into any active combinations themselves, therefore their action is usually termed **Catalytic**. They aid the body in breaking down its food supply so that it can extract the energy and building blocks it needs. Not only our bodies, but Any living bodies — including yeasts!

Now we come to the crux of the matter. Yeast can only utilize very simple sugars for a food supply. Most products in nature are composed of starches, cellulose, complex sugars, and other unsavory materials that yeast cannot use. But **Enzymes** can trigger the breaking down of many of these other materials into simple sugars. For instance the enzyme **Ptyalin** in your mouth starts breaking down starches into sugar before the food even gets into your stomach.

Three Important Facts: First, **Enzymes** are proteins (such as steak

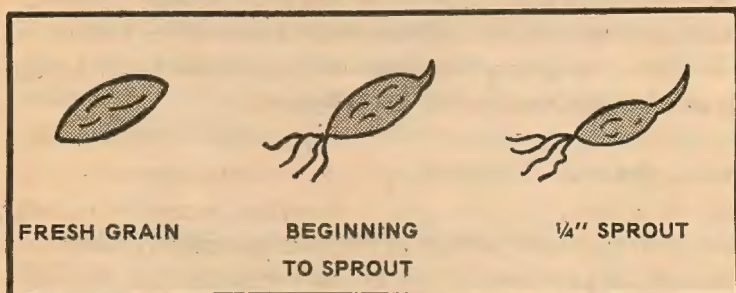
or gelatine) and therefore extremes of heat for any length of time (for instance boiling water) will destroy their effectiveness. Secondly, only a small concentration of enzymes is necessary to cause a complete chemical transformation. A single enzyme can aid the transformation of several thousands of chemical reactions (such as sugar to alcohol) in a single minute. Thirdly, enzymes are very specialized. Although 10 or 20 different enzymes acting independently can cause a very complex reaction, each one is very specialized and can do only a single, very simple, step. And it can only do that same simple step over . . .and over . . . and over . . . and over.

Grains are primarily starch. However, they contain a group of Enzymes called Amylases, one of which will help reduce the starch to Dextrin (a gummy adhesive used for sizing) and another of the Amylases, an enzyme called Diastase, will further act on the dextrin to help reduce it to the sugar Maltose. Another enzyme present, Maltase, helps convert Maltose to Dextrose. . . a very simple sugar. These enzymes (Amylase, Diastase, Maltase) are natural constituents of grains and some other starchy food products. They normally exist in too short supply to act as catalysts. When a grain sprouts, however, these enzymes multiply enormously to help convert the starchy part of the grain into sugars so the young grain plant can utilize the sugar for food.

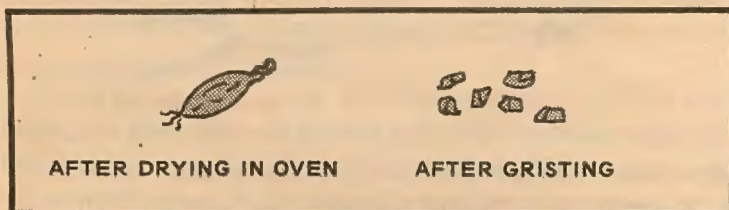


We take advantage of this fact and wet the grain down in a warm place. This “tricks” the grain’s internal chemistry into thinking that spring has arrived, and it starts to sprout which greatly increases the Enzymes (Germination). If we let this process continue for any length

of time, the sprout would soon eat up the food supply and our whole purpose would be defeated. So we let it sprout long enough for the Enzymes to multiply and start the conversions but not long enough for the food supply to be used up in the growing process. This occurs when the sprouts are about $\frac{1}{4}$ " long.



At this point we terminate the process by drying the grain out at a moderate oven temperature of 120 degrees F. or so. This introduces what would be extreme drought conditions on the grain and the sprout dies and withers away. We are left with the enzymes, some starch, some dextrin, some malt and some dextrose (and the hulls, too, of course). It is now called Malt. Our next step is to set up the ideal conditions for the enzymes to finish their job of conversion of the Malt into Dextrose. The grain is converted to Grist and immersed in water in order to allow the enzymes and grains to circulate freely and come into maximum contact. The Diastase and Maltase enzymes convert more rapidly at moderately high temperatures and after adding water. This is the second stage of the process. The liquid conversion temperature is usually anywhere from 130 to 150 degrees F. Some reliable sources recommend 154 degrees as the ideal "conversion" temperature.



After the conversion to Dextrose, the temperature is reduced because the yeast – which are added in the next step – are very much more sensitive to extremes of temperature than are enzymes. More water is added to the mash, if needed, after cooling. Then yeast are added after it has cooled down to 90 degrees F. or less. The yeast produce their own enzymes, Zymase, which converts the Dextrose to Alcohol and water. It is a long chain. Each step of the way is paved with an enzyme performing its single function.

It should be clear as to why a good many recipes called for only a small percentage of the total grist to be malted. A relatively small amount of enzymes will perform an enormous amount of conversions. At elevated temperatures (so long as they are not too high) the conversions take place even more quickly. Obviously, the smaller the percentage of the malt present in a mash the longer you are going to need to brew it.

PREPARATION OF WASHES FOR DISTILLATION

The Wash cannot simply be dumped into the still for distilling. All washes will have a fair number of impurities in them and grain washes, especially, may be saturated to the point of being soupy. If this mixture were put into the still you would soon clog it up. The wash should be either syphoned or carefully poured off of the dregs (bottom sediment) as a first step in cleansing. Always be careful from this point onward not to aerate your products any more than necessary. Undesired byproducts will be formed if you keep stirring in more oxygen and other air-borne material. This is directly opposite to the procedure given Before the yeast were added - when you intentionally stirred in air to help the ferment.

After the dregs have been discarded, the wash can be left set for a few hours or even days for further settling. Usually by this time, it is clear enough to be distillable if it is carefully syphoned once again. The cleaner the wash material is kept the easier the still will be to operate. And the longer between cleanings!

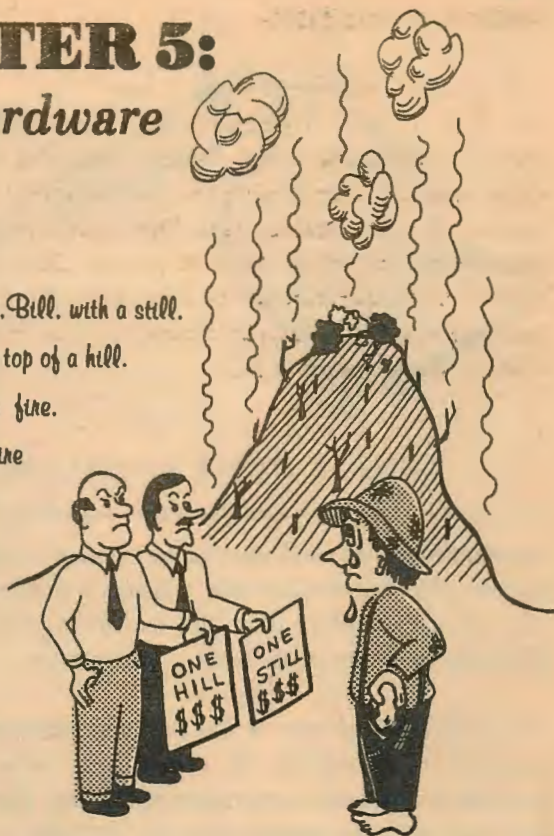
FREEZE DISTILLATION

The common home freezer can be used to effect a fair distillation. The Wash is kept in the freezer until it turns mushy. It can then be poured or ladled into a large strainer cloth and squeezed dry. The liquid squeezing out will be higher in alcoholic content than the frozen residue left in the strainer cloth. This method works well enough to make "fortified" wines (20 to 30 percent alcohol) out of ordinary wines. The temperature of the freezer, length of time frozen, and techniques used to reclaim the Ethanol all enter into determining how efficient the process will be.

CHAPTER 5:

Still Hardware

There once was a man, Bill, with a still.
 That Bill built on the top of a hill.
 When he started the fire,
 The hill burned entire
 And they billed Bill
 for the Hill
 and the Still.



This chapter is approximately in the center of the book. Since it is the heart of the book its placement is appropriate! In this chapter we show and explain the hardware that is used for DISTILLATION. There are many degrees of sophistication in this equipment. We will touch upon all of the major types of stills and cover in greater detail those stills that are practical to build for small and medium size outputs. These latter stills use, in general, materials and components that can be easily obtained in any civilized country.

SINGLE-STAGE STILLS

Figure 1 shows a basic Retort Still diagram. This is the simplest still

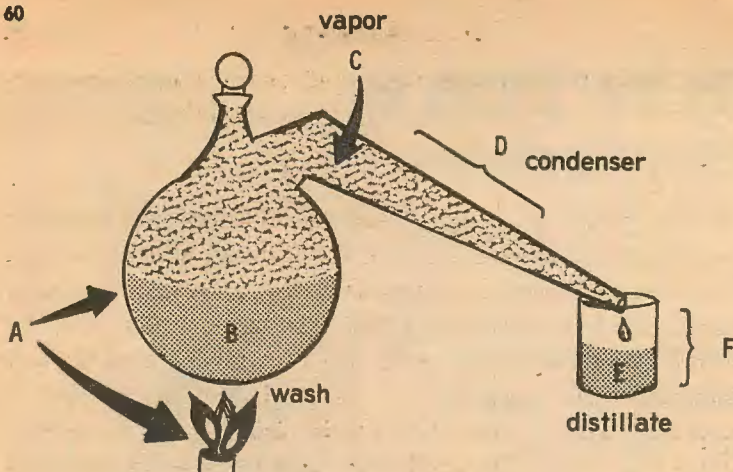


Figure 1: **SIMPLE RETORT STILL**

possible. From it we can define the terms used in distilling and then move on to more practical models. A Retort is simply a glass flask, or bulb, with an elongated tube built into the top. It is designed for distillation on a very small scale in laboratories.

The Still itself consists of the so-called hardware (in this case glassware) in its entirety. In Figure 1 the letter A denotes the evaporating vessel and its provisions for heating. The Wash is denoted by B (also called the Residue after the distillation is completed), the Vapor by C, the Condenser by D, the Receiver by F and the Distillate (or Condensate) by E. At this point, fix these terms fully in mind. They apply to any and all stills and distilling apparatus no matter how complex or simple.

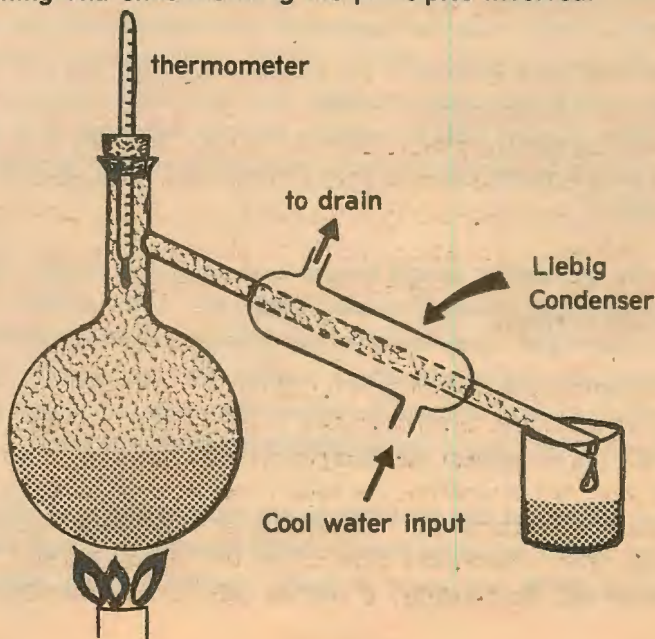
The trouble with the simple retort still is that it is inefficient, slow and cannot handle large quantities. It cannot cool the vapor fast enough. It's no problem vaporizing as you need only apply more and more heat. But to condense, you need to cool the vapor down to condensing temperatures (the temperature at which vapor turns to liquid). This temperature depends on the liquids involved, the pressure and the humidity. If you are only barely vaporizing the

liquid, then it is easier to condense it all, as only a small amount of heat must be removed from the vapor to accomplish this. But such a process would be incredibly slow.

We can improve this Simple Retort Still by making the condenser more efficient as shown in Figure 2. The condenser tube is lengthened and an enclosed water jacket is put around it. Cool water is then forced through the jacket from the bottom inlet upward. This keeps the coolest part of the jacket at all times toward the condensate or distillate end and, hence, increases the yield. This improvement (in laboratory models) came just prior to the Civil War, and is credited to Justus van Liebig. The credit turns out to be evidently misplaced. However it is called the Liebig Condenser to this day.

Figure 2: ADDITION OF LIEBIG CONDENSER & THERMOMETER

For laboratory work in distillation. Although not practical for large scale production, such stills are of much use in explaining and understanding the principles involved.



Another deficiency of the simple retort still design was the lack of any device to indicate when the Ethanol was going, going, gone. If you don't shut the still off at the right time, it simply undoes its good work and adds more and more WATER to the Ethanol that has been distilled off. Because of the rather drastic change in temperature occurring when the last of the ethanol has boiled off, a thermometer is always used in the evaporating vessel or in the vapor, and referred to constantly as the distillation proceeds. Figure 2 shows these basic improvements.

Another difficulty encountered and solved was the tendency of a simple still to be "sloppy" in its work. As is well known, water DOES evaporate without any external heat supply. Obviously, it evaporates even faster when heated. So while the Ethanol is BOILING off, a fair amount of water is EVAPORATING off at the same time, resulting in a MIXTURE of Ethanol and water in the distillate. In Chapter 3 we mentioned that a mixture of liquids in a simple still resulted in a rather imperfect first separation. It is true that much more Ethanol than water ends up in the distillate, but it is also true that a lot of water makes it over the hump. In Chapter 3 we also mentioned that the only cure for this in a simple still is to run the distillate through the still again — and perhaps again and again. Each time it will become purer and purer Ethanol until the solution becomes Azeotropic at a concentration of 97.2 percent Ethanol by volume. Can you faintly recall all of that?

In the next section we will discuss these latest deficiencies. Other noteworthy improvements for simple stills are 1) the addition of a safety valve, and 2) enclosing the system entirely so that no distillate can evaporate into the atmosphere. A safety valve can be easily added by drilling a hole in the top of the evaporating vessel then plugging the hole with a heavy, round marble (slightly larger than the hole).

You will note at this point that we are using examples of Ethanol (Ethyl Alcohol) and water because that is what this book is all about. However, all we are saying is equally applicable to any solutions

capable of being separated by distillation. Even solutions of dozens of different liquids, as we shall see later on.

In a simple still, the first portion of the distillate to condense is called the Heads and it is the purest. The last portion to come over is called the Tails and it is the most dilute and most likely to contain any contaminants present such as Esters, higher alcohols, etc.

Since we will be discussing proofs to some extent from this point onward, it will do to mention that in the United States a Proof Gallon of liquor contains 50 percent Ethanol by volume (NOT 100 percent as is sometimes believed). All tax rates are given in terms of Proof Gallon and liquors containing more or less than 50 percent are taxed on the percentage that they do contain — which is a fair system since it is only the Ethanol that is taxed.

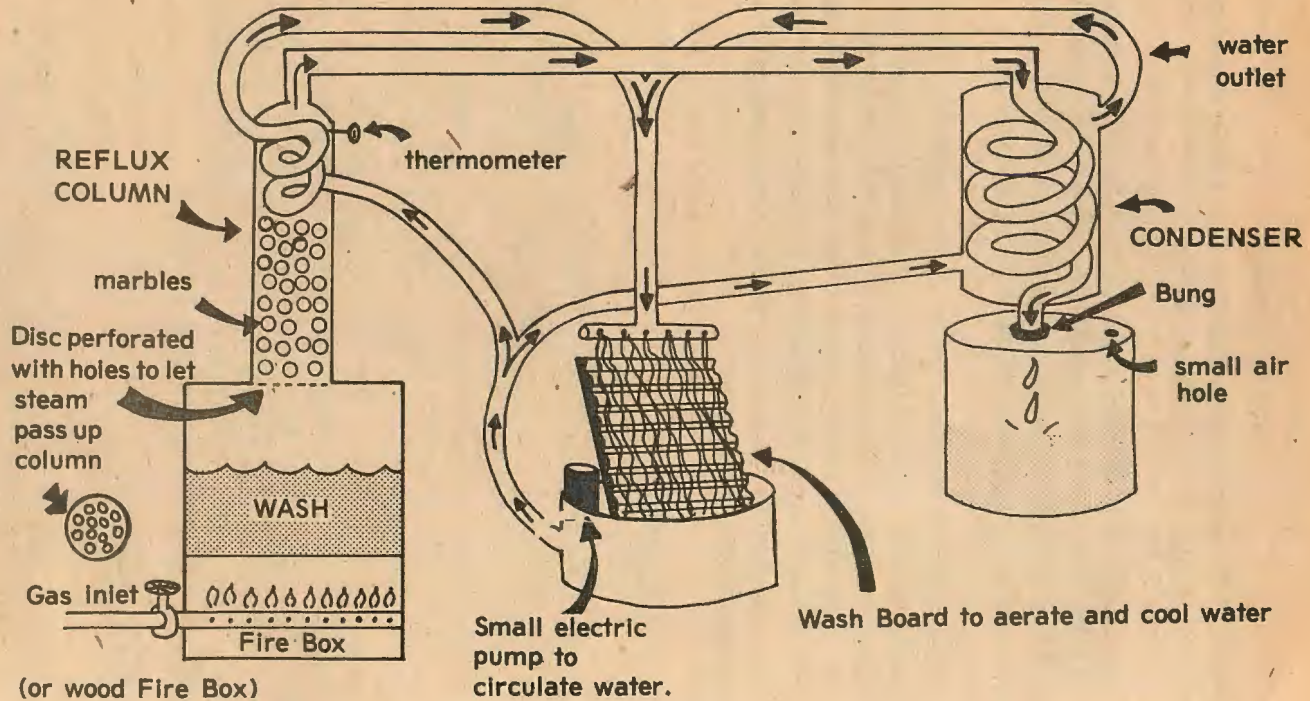
COMPOUND STILLS

Most of the stills and innovations discussed up to this point are useful only on a laboratory scale. The simple pot still (to be discussed later) produces only a small fraction of the total liquor in the United States, Great Britain and Canada. Compound Stills have a greater degree of sophistication built into them and are faster, cheaper and simpler to operate. The Compound Still is practical on either the laboratory or commercial level. Thousands of different types have been built and tried by engineers, moonshiners, and bootleggers alike. In this section we will cover primarily those designed by the engineers. In the final section we will offer some versions cooked up by various moonshiners and pot boilers over the years. More than one moonshiner could very well have qualified for a degree in engineering!

REFLUX STILL

Figure 3 is a simple, but quite workable, Reflux Still. It is a classical type built by professionals and amateurs alike. It is an excellent type for illustrating basic principles. Probably more variations of this type

Figure 3:



have been built than all other types combined. As you will notice there is no radical departure from what we have discussed here-to-fore except for the Reflux Tower or Reflux Column mounted on top of the still. The Wash container is fitted with a gas fueled firebox to operate from natural gas or propane. This makes it easy to adjust the heat input to close tolerances. The Wash box needs to be stainless steel or some other equally inert material as the hot wash increases the activity of the acids. Copper is also used but needs to be kept very clean between uses to avoid corrosion.

The Reflux Column is mounted on top of the Wash box and welded or bolted securely to it. A stainless steel disc, perforated with many small holes, is all that separates the Wash Box from the inside of the Reflux Column. The Reflux Column is filled with large round balls of a non-porous, non-active material such as ordinary marbles. Obviously the holes in the perforated steel disc must be smaller than the marble diameters or the marbles will simply fall through into the Wash Box and stop the whole operation. Sometimes such things as wire helices and-or Stainless Steel Wool are used in the Reflux column in place of the marbles. Many other items will work, but they must be made of a material that is relatively inert to mild acids.

The operation of the Reflux column is disarmingly simple. Since water vapor travels with the lower-boiling Ethanol into the distillate, a simple way to prevent the water vapor from making it over into the distillate is to start cooling all the vapors JUST A LITTLE BIT before they travel over into the condenser. With much cooling ALL the vapors will tend to start condensing back into the liquid state and fall back down in the reflux tower. However, by providing only a tiny bit of cooling the component that is going to condense first is going to be the one that has the highest boiling point — water. The marbles provide a small degree of isolation from the heat and a little condensation of the water starts to take place. The marbles also provide a large surface area on which the condensation can occur. Naturally the coolest marbles are at the top and most condensation will occur there, and, under the influence of gravity, start dropping downward back into the Wash Box.

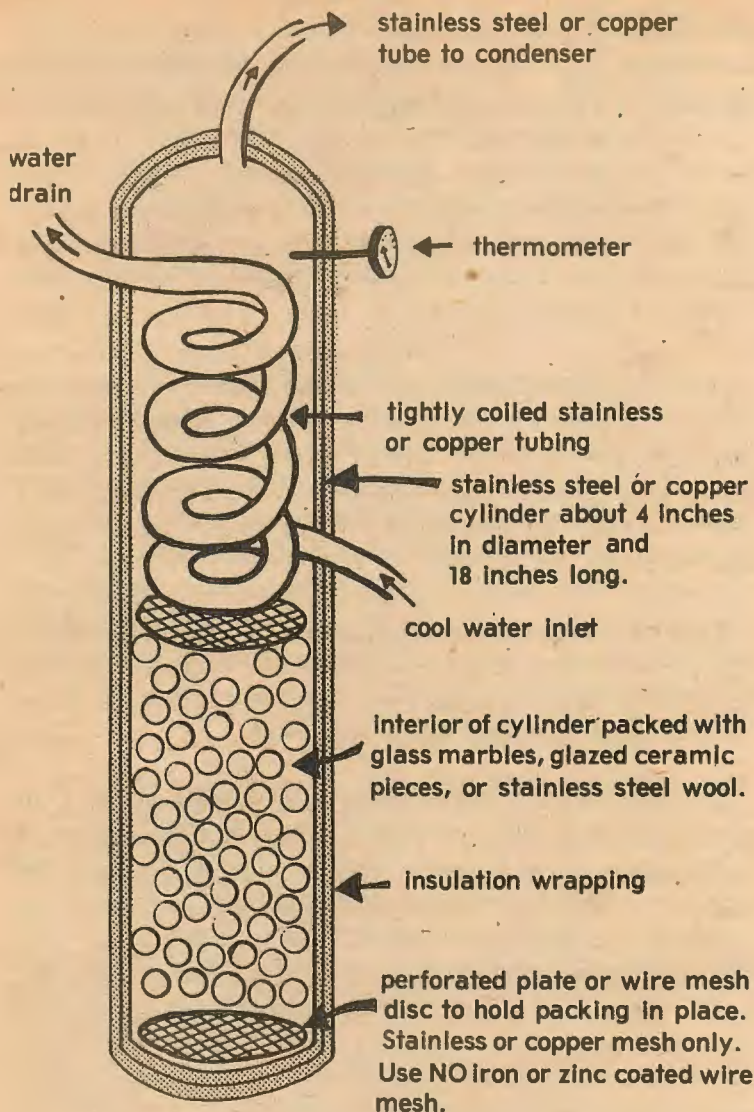


Figure 4:
**ENLARGEMENT OF TYPICAL REFLUX TOWER
 SHOWN IN FIGURE 3**

Of course, some Ethanol also condenses out on the cooler top marbles but as the liquid descends, and the marbles become warmer and warmer, the Ethanol will tend to evaporate first and go back into vapor and proceed upward again. Inverse or Reflux action takes place. The vapor traveling upward tends to become purer Ethanol. The vapor traveling downwards tends to become purer water. It actually becomes a two-way distilling system. A SINGLE RUN THROUGH A REFLUX STILL WILL USUALLY BE WORTH THREE OR FOUR RUNS THROUGH A COMMON POT STILL. This should give you an idea of the enormous efficiency afforded by a reflux still design. A typical single run through a pot still may yield a distillate containing 20 to 30 percent Ethanol from a wash which contained perhaps 10 percent Ethanol. A single run through a reflux still of fair design can yield a distillate in excess of 90 percent (180 proof) from the same wash!!!

Some other improvements are afforded by the design in Figure 3. The condenser is an elaborate version of the Liebig condenser with many, many coils of stainless steel or copper tubing wrapped tightly inside a water tight tank. The receiving barrel needs no comment other than to say it should be appropriate for a food product — plastic lined, wood or stainless steel. In order to avoid throwing away an enormous amount of water — in the best of ecological tradition — a recycling operation is set up. A small electric pump operated from a battery or house current pumps water through the water jacket on the Liebig condenser. In order to help cool the water, a corrugated wash board is set up inside the tub and the return water is allowed to flow over these ribs in open air on its way down to the tub. Some of the liquid evaporates in so doing, and this in turn cools the remaining liquid. Of course, because some water evaporates on a continuing basis it will have to be replenished from time to time. But not nearly so much nor nearly so often as if the water was simply thrown away.

If there is a creek or stream nearby this tub affair is not necessary. The water can be pumped or channeled from upstream and ejected a little ways downstream. Unless some gigantic operation is underway,

this will not heat the water to any measureable extent even a few feet downstream – it won't upset any ecological balances.

FRACTIONAL DISTILLATION

Fractional Distillation has little to do with the efficient construction of Stills for Ethanol. However this is an excellent opportunity to see how other fields use Distillation Techniques – in this case the oil industry.

Fractional Distillation takes place in a Reflux still put to very sophisticated use. Recall that we mentioned previously that a still not only can separate two components mixed together but even dozens. One very good use for such a still is the separation of crude oil into all of its basic components. Crude oil contains such things as Propane, Butane, Octane, etc. all of which have different boiling points. Of course we know them better as Gasoline, Naptha, Kerosene, Fuel Oil, Lubricating Oil, Grease, Paraffine, and just plain old tar. But they are all contained in crude oil and need to be extracted to keep the industrial revolution from becoming an insurrection.

Figure 5 shows a sophisticated reflux fractionating column. Of course, you realize that highly paid engineers are not going to use anything so simple as marbles in their columns. This column uses a very popular and efficient method known as the **Bubble Plate Column**. The principle is the same, however. The rising vapor Bubbles through the liquid and around the plates on its way upward and passes through several consecutive vaporizations and condensations. The liquid flows down through the tubes. At various points upward on the column the level of volatility will be correspondingly different and a hole cut through the surrounding jacket at that point will release all those vapors falling within a certain range. Notice that this is a Continuous still in that the feed point is above the bottom of the still. Thus it works downward also in an inverse manner and the materials Denser than the average of those coming in, such as pitch and tar, exit through lower portions of the column. Many commercial Ethanol stills are also of this continuous action design.

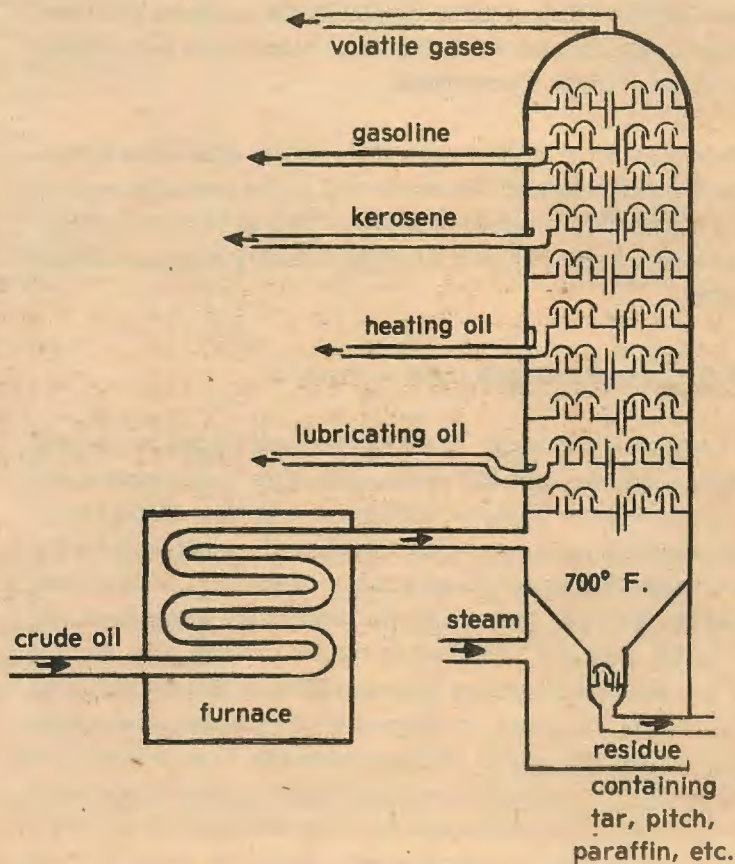


Figure 5:

MODERN, CONTINUOUS RUN FRACTIONATING COLUMN
FOR SEPARATING MANY DIFFERENT COMPONENTS
SUCH AS CRUDE OIL AS PICTURED HERE

HOME-MADE STILLS

More stills have been built by the home enthusiast throughout history than there probably are people. That would make over 4 billion to date which seems like a reasonable number. Most of these were useless and many blew up taking their lackluster designers with them. But some were successful and a few even brought forth technological innovations of historic proportions.

We have gathered together a few of the popular ones in this section. If you have concentrated reasonably well on the preceding sections and chapters, they will need little explanation as to their workings. Some notes are added where it is thought necessary to explain unusual features.

POT STILL OPERATIONS (refer to Figure 6)

If the mash is very soupy, do not fill these pots too full, or they will clog the condenser lines with mash solids. After heat is applied, the first distillate starts dripping into the receiver at 170 to 180 degrees F. Any distillates coming over before 170 degrees F. should be discarded (small amounts of Methyl alcohol and other impurities). Keep the heat moderate. Within an hour or two, the temperature should gradually rise to 205 degrees F. The heat is removed at this point and the distillate should be about 40 to 60 percent Ethanol. This is a very good yield for a pot still in one run. Discard the residue and clean out the entire still and tubing after each and every run. If purer Ethanol is desired, repeat the operation exactly as above to get a yield of about 70 percent Ethanol. Remember that the slower you distill the purer the product. Also remember that it is quite flammable from this point onward. **NEVER LET THE TEMPERATURE EXCEED 210 degrees F.** Watch it constantly!

If more purity is desired, more care needs to be exercised. The heat should be applied carefully (slower) as the action is rapid. Stop the still action at 180 degrees F. instead of the usual 205 degrees F. This

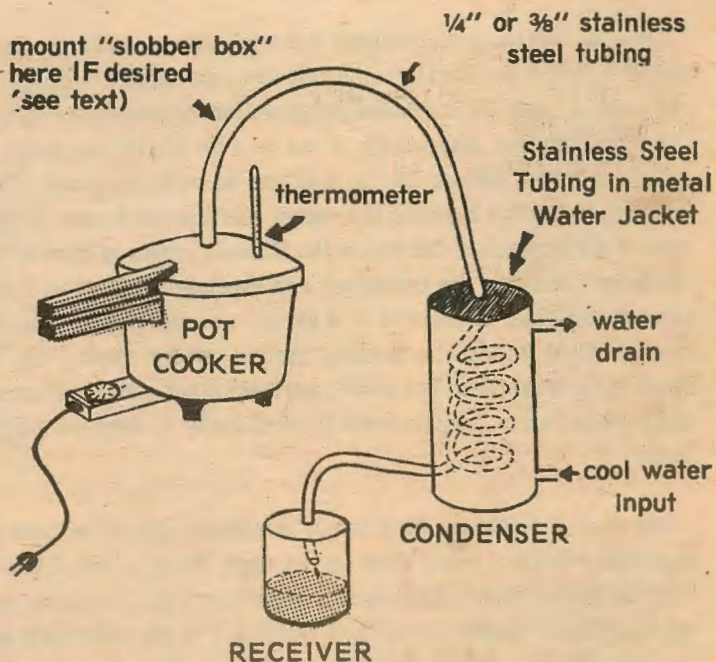


Figure 6:
EFFICIENT HOME POT STILL (Model A)
"Work horse of the ages"

produces about 85 percent Ethanol. A fourth run following these same instructions, will yield Ethanol of 90 to 95 percent.

SLOBBER BOXES

Although this name is indelicate it is one of the common descriptive pieces of jargon invented by some unknown moonshiner. A slobber box can assume many different configurations but the one shown in Figure 7 is representative. Essentially, it can be a tin can or aluminum can, square or round, with simply an inlet and an outlet as shown. This is mounted in the line between the cooker and the condenser. It allows most of the impurities that follow the Ethanol across to have a "drop-off point" ahead of the condenser and receiver. This gives a much cleaner distillate. In practice it is simply an enlarged portion of the tubing where solids, particulate matter, water vapor, etc. can recondense or drop out. The small hose leading out of the bottom of the slobber box can be used to drain it periodically to keep the pathway clear.

The use of a Slobber Box is not mandatory but it is desirable, especially where a reflux tower is not used. When a reflux tower is used the tower, itself, performs this same function. If a slobber box is not used then a larger part of the FIRST part of the distillate coming through should be discarded. For a six or eight quart pot cooker without a slobber box it is advisable to set aside the first few ounces coming through. Since this is bound to also be very rich in Ethanol it can be saved and added to a later batch to be redistilled. With a slobber box only a tablespoon or two of the first distillate through need be discarded.

STILL HARDWARE

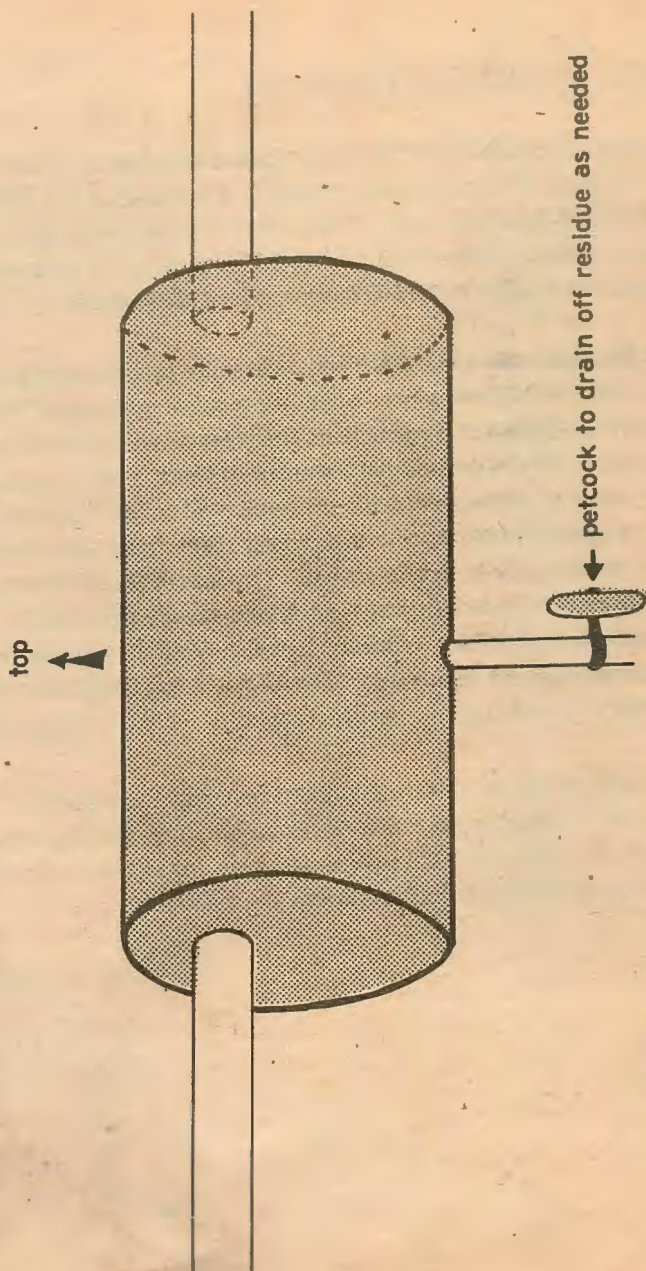


Figure 7:
SLOBBER BOX

THE CONNELLY ICE WATER STILL

Here is the ideal still for the entrepreneur living at the corner of Constitution & Pennsylvania Avenues in Washington, DC. (The IRS is two blocks away, the Dept. of Justice is two blocks away, and the U.S. Court House is right across the street). This is a pretty tricky place to live so the still had better NOT look anything LIKE a still!

The only items needed are some carefully proportioned pans and few feet of half-inch copper plumbing pipes or glass rods. Figure 8 shows the details of construction. The large basin on the top should have a rounded bottom so that the escaping vapor condensing on it will roll to the bottom and drop into the small bowl or cup. The small bowl is suspended in the middle of a tripod made from three carefully measured copper pipes or glass rods. If the size of the three containers is carefully chosen to fit just right a fantastically simple still can be built that is moderately efficient. Ice cubes from the refrigerator can be used in the top pan. All of the still parts can double for normal kitchen use, making this design economical for the crimped budget.

Although this is a charming and deceptively simple still it is not nearly so efficient as other designs. To increase its efficiency somewhat, keep the heat as low as possible. This will allow more of the alcohol to condense before it is lost as an escaping vapor.

porcelain or stainless steel wash basin or large pan that fits moderately snug, but with ample room for steam to escape.

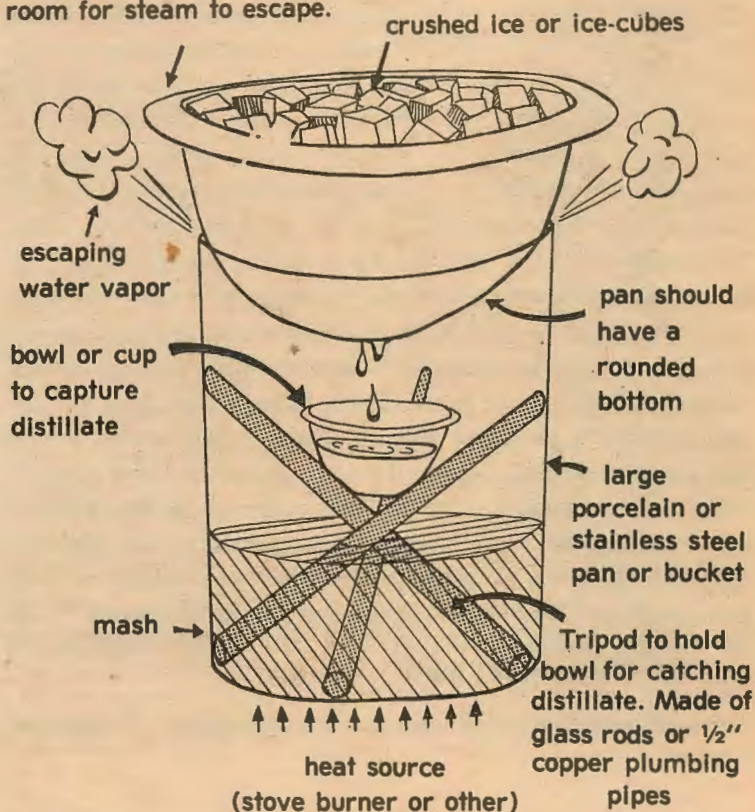


Figure 8:
THE CONNELLY ICE-WATER STILL

HOME POT STILL (Model B)

This still is very similar in construction to the Model A, HOME POT STILL. As with the Model A, the pot, cooker is usually a converted pressure cooker which can be electric or stove-top variety. The heat should be easily adjustable so that it can be turned low as soon as the temperature on the thermometer reaches the area of 170 degrees F. The tubing leading from the cooker can be a flexible plastic or rubber type that is sold as "food-grade" material. It will fit tightly over the center outlet on the cooker where the pressure weight usually sits (such as on the Presto Model 106 series cookers) and requires NO modification of the cooker lid. There is a small rubber grommet on these lids that contains a little metal pivot that is used as the safety valve. If the grommet is left intact but the metal pivot removed, a thin thermometer will fit through the grommet snugly. Again no modification of the lid is needed and the safety valve can be put back together again. If too much pressure is allowed your thermometer will be blown out of the lid so keep this in mind and always be sure that the generated steam can be heard hissing through your pipes into the slobber box and condenser radiator. The thermometer will always give you prior warning however if you are prudent. A higher pressure in the cooker is going to cause the temperature to rise also. So if you get a sudden and rapid increase in temperature shut down the operation and check for plugged lines (after the pressure and temperature drop to low values — temperature below 150 degrees F). **IN NO EVENT SHOULD YOU ALLOW THE TEMPERATURE TO EXCEED 210 degrees F. Watch it constantly!**

The slobber box is constructed and operates exactly as described previously.

The biggest real difference in the operation of this still is the very efficient and very easy-to-operate air conditioner radiator. These radiators normally are constructed entirely of copper tubing and you should check for this before using it. The radiator should be clean appearing and should be flushed before usage with hot soapy water (with degreaser added) and then with boiling hot clear water. If done thoroughly this will get rid of any oils or greases and other soluble

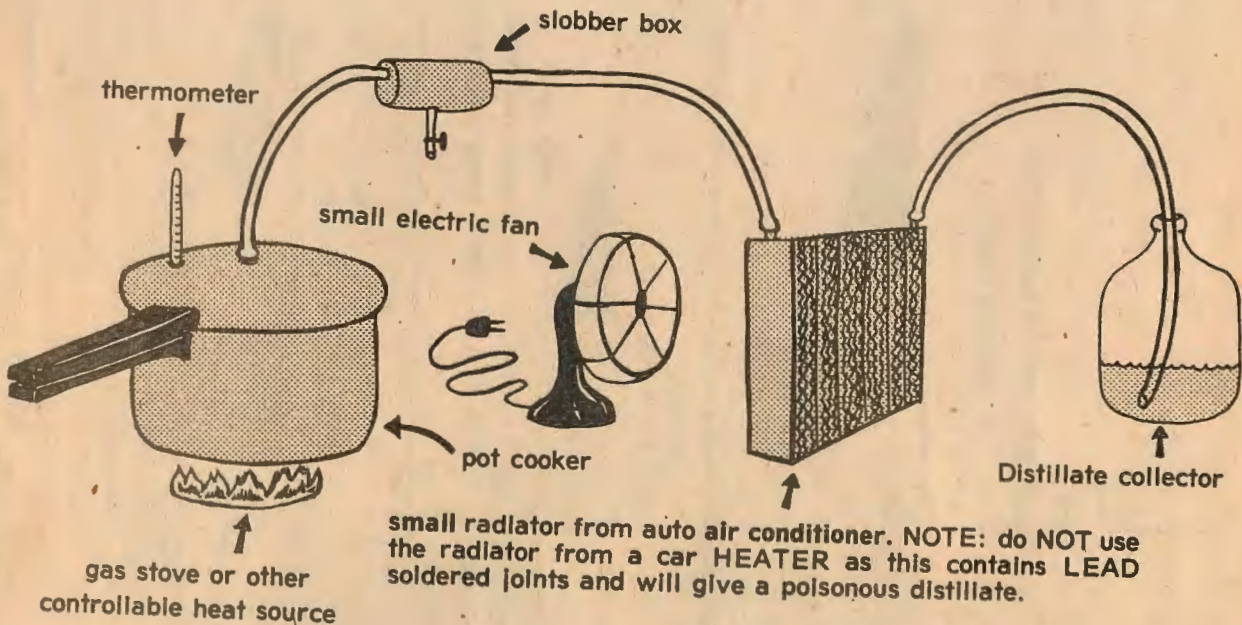


Figure 9:
HOME POT STILL (Model B)

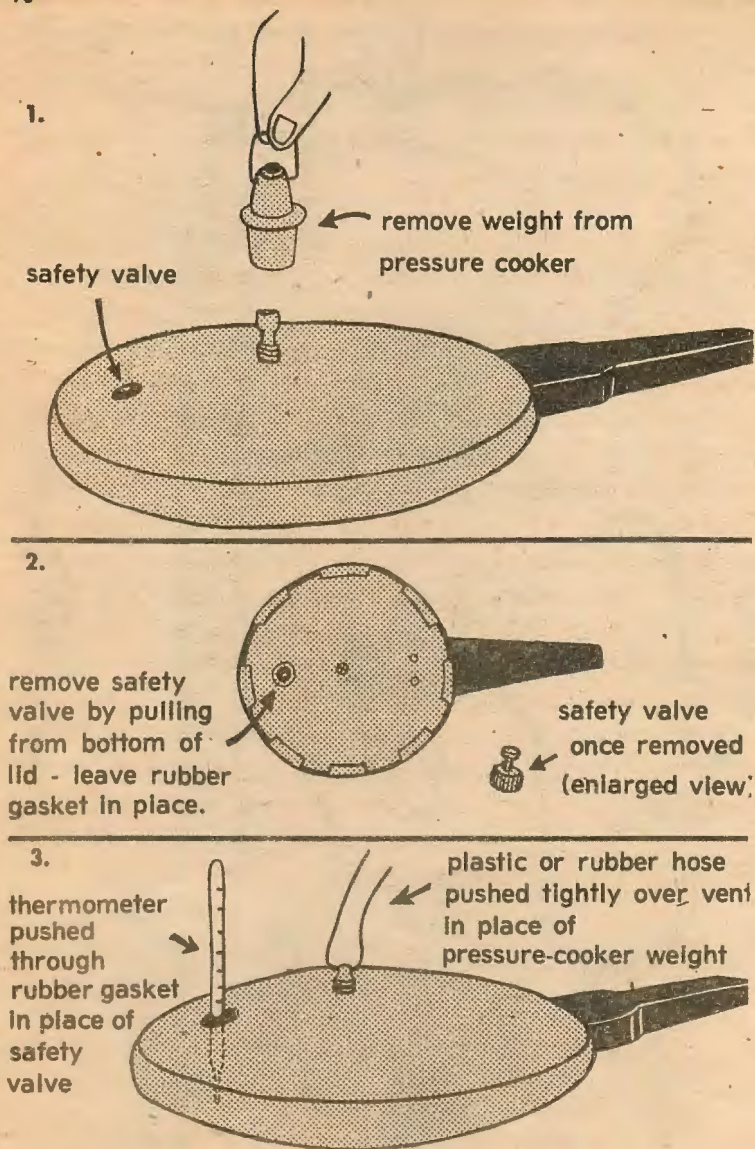


Figure 10:
**CONVERTING A PRESSURE COOKER LID
 FOR USE AS A STILL**

contaminants that might have settled there. After the still is first set up the pot cooker should be filled with pure water and this should ALL be boiled and run through the tubing and condenser into the distillate collector. This should pretty well finish cleaning up the entire apparatus. Then drain everything, clean it up, and start the first batch of mash or wash through the still.

In operation you need a small electric fan to adjust the operation of the condenser. The fan performs the same function as the running water does in the normal water-cooled condenser. Remember, however, that the normal air conditioner radiator is very, very efficient and it will not take too much air current to keep it running plenty cool. If you use too much air the radiator will run too cool and the radiator will act as the distillate collector and it will all condense there. On the otherhand, if you don't have enough air circulation the radiator will run too hot and steam will come out of the tube leading into the distillate collector. Which means you will be losing a good deal of your Ethanol vapor into the air. It is sometimes best to put a piece of cardboard over the half of the radiator toward the collector bottle (thereby blocking the air from the fan on that half). Thus most of your cooling will be directed over the uncovered half of the radiator closest to the pot cooker. A little playing around with the cardboard will allow you to find the optimum position for the fan and the cardboard. Aside from these small differences in construction and operation the still should operate in the same manner as the **Model A POT COOKER STILL** and the same general instructions and admonitions apply.

CONTINUOUS RUN STILL

This still is a very simplified Continuous Run Still. The wash needs to be well strained or made from a **Thin Wash Recipe**, as any particles will gum up the works. Briefly, the wash travels down the syphon tube and strikes the hot bottom plate of the soldering iron (heat source). This vaporizes most of the Ethanol which bubbles up through the small amount of water in the bottom of the soldering iron, and enters the tiny reflux tower on its way to the receiver. The water that precipitates from the reflux column joins the water already present in the bottom of the soldering iron and exits through the drain tube located about an inch above the top of the soldering iron head.

Notice that the soldering iron tip has been removed and replaced by the stainless steel reflux column. The whole system operates in a precarious balance between two controls ... the wash flow control clamp on a rubber section of the wash delivery tube, and the faucet, which controls the condenser cooling rate. The wash flow clamp adjustment is the most precarious one. The syphon is started by blowing in the syphon vent tube until a few drops of the liquid come out the **Residue Drain Tube**. Then it is pinched off until the temperature reaches 195 degrees F. or thereabouts on the thermometer. At this point the flow rate is adjusted by trial and error until the temperature settles in at around 195 degrees F. It will then continue to run and distill until all of the wash is gone. The wash jar can be filled many times over while the still is in operation to give a continuous running still, if desired. Eventually, it will have to be shut down for cleaning. A little lower temperature than 195 degrees F., say 190 degrees F., will yield a faster run, but the concentration of Ethanol will be less. A single run through this still will produce alcohol of at least 100 proof (50 percent). This type of still is not well suited for multiple runs as it is a delicately balanced operation. But it is very well suited for single runs. Any other adjustable heat source could be substituted for the soldering iron. Diagrams of this still are found on the next two pages.

Electricity is connected after unit is filled,
and is disconnected before breaking syphon

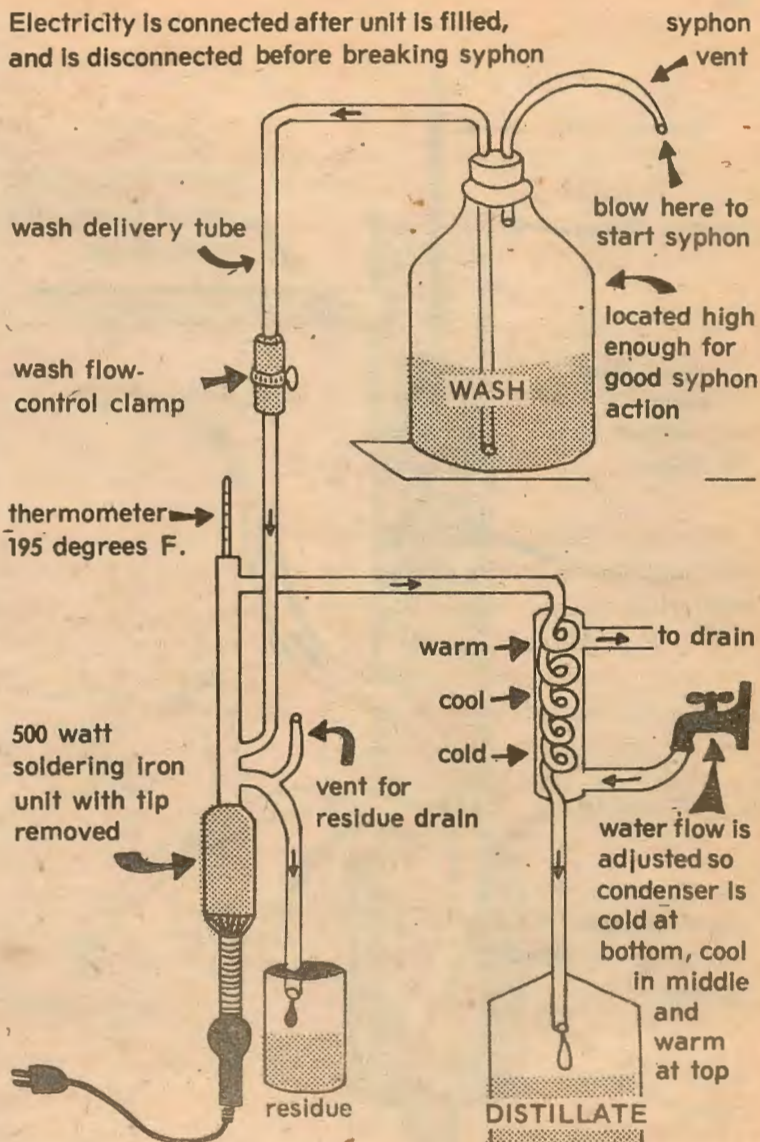


Figure 11:
CONTINUOUS RUN STILL
also called "sneaky home still"

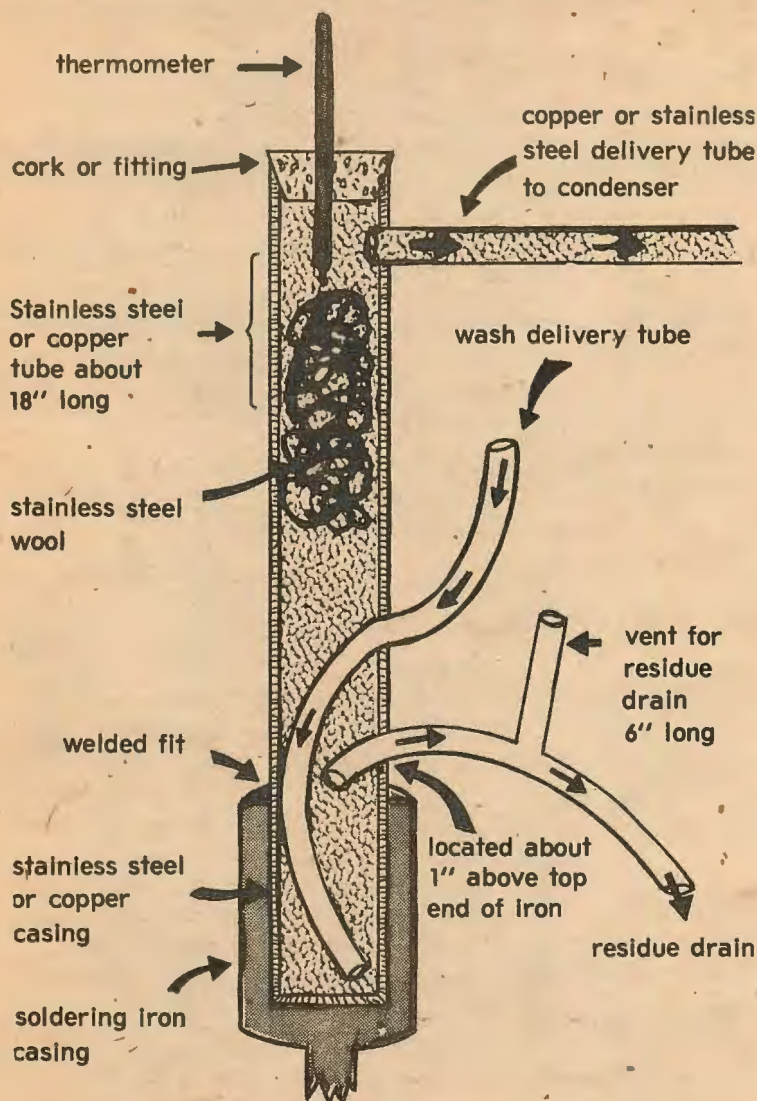
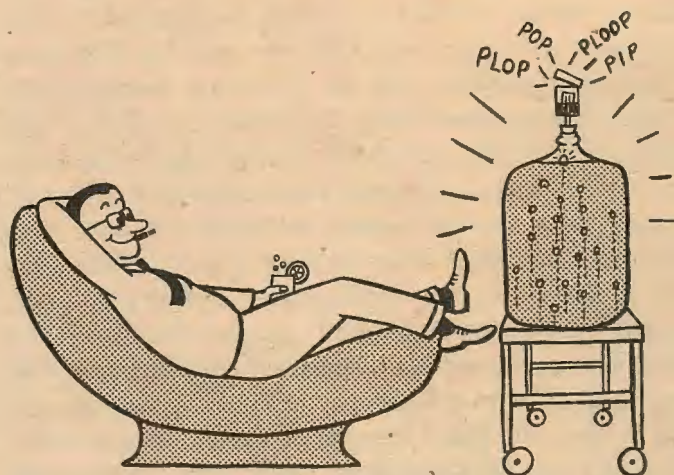


Figure 12:
ENLARGEMENT OF HEATING ELEMENT
 PORTION OF FIGURE 11

CHAPTER 6:

Fermented Beverages



BEER & WINE FUNDAMENTALS

Now that we have covered all that the book title obligates us to cover, we can sit back, relax, and talk about alcoholic beverages that you **Can Legally** make in your own home — and **Tax Free.**

FOR PERSONAL USE & CONSUMPTION

Any single adult (adult by state legal standards) can make 100 gallons of wine or beer per year for personal use and consumption. This is a Federal law and applies so long as no state law prohibits it. Almost all states allow the free production of home wine and beer. However, check with your own state authorities or your local home wine supplies store as laws have a way of changing from time to time. A husband and wife can make 200 gallons of wine or beer per year. So there is no reason to run dry if you make your allotment. 200 gallons per year means more than 2 quarts per day.

FERMENTATION

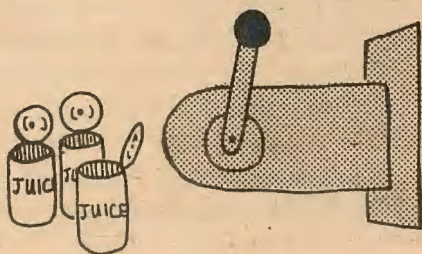
Both wine and beer begin as a fermentation. To set the record straight, let's define a few terms. Fermentation is the primary means by which most drinkable alcohol is produced. Fermentation is easily started by using almost any fruit, flower or vegetable juice and a yeast. What is fermentation? And, for that matter, what is yeast? Yeasts are microscopic plants that are all around us in the air, much like pollen except smaller. Yeasts are Not bacteria. Bacteria are small microscopic animals. So yeasts and bacteria exist on a small (microscopic) scale much as animals and plants exist on a large (macroscopic) scale. Which brings us to fermentation. Yeasts feed primarily on diets rich in some carbohydrates (sugars) and, like all plants, need phosphates and nitrogen to prosper. When yeasts are flourishing in a heavily sugared environment (such as fruit juices) they keep their life processes going by assimilating the sugar and breaking it down into Equal amounts of Carbon Dioxide (which bubbles off as a gas) and Ethyl Alcohol (which is the drinkable kind and stays in solution). This process of yeast growth is called Fermentation. Fermentation is the process by which all wine and beer and most alcoholic beverages of Any kind, are produced; whiskey, gin, vodka, scotch, etc. start out this way.

If you start your fermentation using a grain such as barley and then bottle the fermented product before it is completely through fermenting, it builds up pressure inside the bottle (from the fermentation which releases the inert gas Carbon Dioxide) and the result is usually called Beer. Beer is usually low in alcoholic content because the amount of Barley used in the drink is kept low intentionally. If you start your fermentation with a liquid richer in sugars using Any vegetable, fruit, or grain as a base and simply let it ferment out completely, or nearly so, more alcoholic yield will be realized and the result is called Wine. The usual fermented beer contains about 3 percent to 8 percent alcohol. Wine is normally anywhere from 8 percent to 20 percent alcohol.

MAKING WINE

To learn to make a good wine it is best to start with a kit for the first few batches until experience is gained. These kits contain their own instructions. In this section we will give a brief outline of the steps necessary to prepare your own wine starting from a frozen fruit juice concentrate. Orange juice makes a good choice as it is reasonably well balanced for wine making and produces an excellent light wine very similar to white grape. We will outline the instruction for a single gallon. If you wish to make 4 or 5 gallons merely multiply the recipe in the usual manner.

Start with enough cans of concentrate to make 5 quarts (1 gallon plus 1 quart). Do not mix with water yet. Open the cans of concentrate and place the contents in a large open



container (polyethylene plastic or stainless steel). Add 4 heaping cups of cane sugar. Add 3 quarts of very hot water and stir this mixture to

dissolve the sugar
• and thaw the concentrates.

After this is thoroughly mixed and dissolved, add enough water to bring the total in your pan or container to 5 quarts. This is



your basic Must as it is now called. Add the peeling from a freshly peeled orange or apple.

You will need to purchase some Campden tablets (or sulphite) and some wine yeast from your local Home Wine Supply store. Add one campden tablet (after first crushing it to a powder) and stir it into your must. Stir your must well, cover it loosely and leave sit for about 24 hours. Then add your wine yeast. Shake or mix thoroughly again. Cover loosely with a clean cloth, lid or aluminum foil. Fermentation will commence within a day or two. Keep temperature about 70-75 degrees F. It is not absolutely necessary to stir or mix again, but you can stir every day or two for the first four or five days. After about 10 days to 2 weeks, carefully pour or syphon the liquid through a funnel fitted with a coarse nylon mesh or cheesecloth. Discard the pulp and thick residue at the bottom of the container. The remaining liquid can then be put into a narrow mouth jug or jar of the proper size which, in turn, can be fitted with a fermentation lock or simply capped Loosely (Do not ever tightly cap or close a fermenting container.) Fermentation locks are much preferred and can be purchased from your local Home Wine Supply store.

If you are going to use the same open container again (instead of a narrow-neck jar and fermentation lock), cover the surface of the liquid with a sheet of plastic film or wax paper before replacing the lid or cover (remember - cover loosely!!). This plastic film or wax paper should be replaced about once a week, and will serve to keep the surface air from contacting your wine.

Syphon the wine off of the dregs again about three weeks later and then again in another three weeks. If kept in a cool place (But Not Cold!) during this time, the wine should clear by itself (about 65-70 degrees F.). As soon as the wine has sufficiently cleared, it can be bottled. At this time it should taste tart or acidic - similar to insufficiently sweetened lemonade. Your wine can be drunk anytime after the third or fourth week - even before it has cleared - but the longer you wait the better it will be.

PRESERVING YOUR WINE'S FLAVOR

Most modern recipes call for a short initial vigorous fermentation with only a loose covering over your wine (lid or cloth), followed by a longer period of slow fermentation when the wine is protected to a greater degree (by an air lock) from coming into contact with the free air. This first period usually lasts from 1 to 2 weeks and is termed the Primary Fermentation. The second period covers anywhere from a few weeks to a few months depending on the recipe, temperature, etc. and is called the Secondary Fermentation.

The Primary Fermentation is marked by a bubbly appearance and usually some frothing at the top. The Secondary Fermentation is the longer period of slow activity. During the primary fermentation most recipes do not encourage you to protect the surface of the liquid from the air. There is good reason for this. If the fermentation is quite brisk it may bubble up over the top of the container and through a fermentation lock, if one is used. This creates quite a mess and for no good reason. Since carbon dioxide is a fair amount heavier than air, the trapped carbon dioxide in the bubbly frothing surface of the Primary Fermentation provides its own protection from the air.

Following this period of high activity, however, not much carbon dioxide is produced and very little froth. Thus the slightest air currents in a room will penetrate through the thin carbon dioxide layer on the surface of the wine and allow the wine to come into direct contact with the oxygen in the air. This is usually not desired. Thus during Secondary Fermentation it is wise to either use an air lock (fermentation lock) such as the common plastic type sold in most wine supply stores or some other method of protecting the surface.

Usually it is recommended that a large open container such as a crock or plastic container, be used for the Primary Fermentation and a narrow mouthed container, such as a jug, be used for the secondary fermentation. It is then customary that during the Primary Fermentation of a week or two the open container is covered with a loose

Types of Air Locks



loose plastic
cover



cotton
plug



thumper



glass or plastic
air lock
(preferred method)

fitting lid or plastic sheet to keep out dust from the air, flying insects, etc. At the end of the Primary Fermentation, the must is then usually transferred to a narrow mouth container. The new container is filled to within an inch or so of the top leaving only a very small surface area in contact with the inside atmosphere of the bottle. The top of the narrow mouth is then fitted with a fermentation lock mounted in a cork or cap. This is a very good time proven method.

However, you should be aware that any shape container can be used throughout the fermentation if desired. For instance, if you have only a narrow mouth plastic or glass container available you can use it for the primary and secondary fermentation by simply cleaning it out each time you rack the Must and replace the liquid for further fermentation. A fermentation lock does not need to be fitted on it for the first week or so.

Similarly an open container can be used throughout the fermentation also. However, since it is difficult to fit on a tight sealing fermentation lock on large mouth containers, some protection can be afforded by cutting a piece of wax paper to the inside shape of the container and simply floating this on the surface of the liquid to exclude contact with the air. The tiny amount of liquid exposed between the edge of the wax paper and the containers inside edges will not matter if the top of the container is covered with a Loose Fitting lid or cloth or plastic sheet to exclude air currents.

Each time the Must is racked new wax paper should be put down. Another solution is to cut a thin wooden lid the size of the inside of the container and Float this on the surface of the liquid. This makes a splendid solution since if it is made from oak it will have some of the effects of aging in oak. It should be boiled thoroughly before using. Plywood should never be used as it has glues and resins which will contaminate your wine. If you use a large plastic open container that has an air-tight snap-on lid be sure to simply place the lid on Loosely after you have floated your wax paper or oak board. Never, Never tightly cap a fermenting vessel unless you like to clean up burst containers.

MAKING BEER

For making a single gallon of lager beer, use a malt extract, lightly hopped, or a similar malt extract. Malt Extract can be purchased at your local home wine store and is also available in some grocery stores. Also a good beer yeast should be purchased. Mix together about 5 ounces of malt extract (about $\frac{1}{2}$ cup) with 1 quart boiling water and $2\frac{1}{2}$ level cups of sugar. Boil together for a few minutes, Stirring Constantly until all has been dissolved. Next, pour this mixture (called Wort) into your large open container for fermenting. Add 4 quarts Cold water. Mix thoroughly and allow to cool to room temperature, or about 70-80 degrees (feels tepid to touch). If your added water was cool then it should be at room temperature immediately. Add the contents of the yeast packet, mix well, and immediately transfer the Wort to a cool place (about 60 degrees F.)

Now Comes The Most Important Part For Making Good Lager Beer
- a cool place for the fermentation to take place (not below 40 degrees, or above 70 degrees). Fermenting at lower temperatures will take somewhat longer than at higher temperatures. The ideal temperature is 60 degrees during the first week of fermentation.

After about 12 to 24 hours, the beer should have active frothing

surface. This bubbling may last from 5 to 10 days depending on the temperature. When the bubbling has stopped, remove the froth from the top carefully (do not agitate the container too much, as the Dregs, or sediment on the bottom will be stirred up and make your beer cloudy). After clearing the top of the liquid, syphon the clear liquid into another container, being careful to leave the dregs behind.

Put the new container in a very cool place again (this time the temperature can even be below 40 degrees, but keep it above freezing). Put a piece of wax paper or plastic sheet on the surface of the liquid to keep off all oxygen. Within three or four days the liquid should be fairly clear. Syphon carefully once again.

PRIMING AND BOTTLING

To Prime (add sugar directly before bottling) your beer, remove about a pint of the new beer and dissolve in it 2 level tablespoons of sugar. Pour the pint back in the main batch, and stir it gently. Be sure it is mixed well, or you will run the risk of bursting bottles. Bottle Immediately After Adding Sugar.



Bottle Caps before and after being crimped on bottle.

Use standard beer bottles or any other bottle which you can securely cap or close. Crown caps usually present the best solution to this

problem. Fill the bottles to within about an inch of the top. Cap and store Upright in a Warm place (70 to 80 degrees F.). It is best to store your bottles for the first few weeks in a place where a breaking bottle won't hurt anyone. This is a rare occurrence, but one worth guarding against. The beer can be drunk in a few weeks, but a month or two gives a better aged beer.

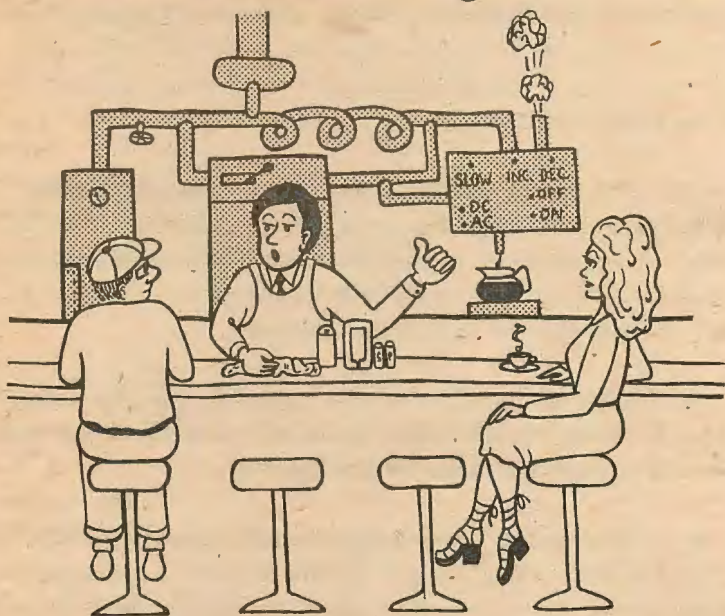
Chill beer before serving, Keep In An Upright Position in refrigerator, handle gently to avoid stirring up any sediment. Pour slowly and smoothly into a glass large enough to hold the contents of the bottle. When the powder on the bottom of the bottle starts to pour out, stop pouring, and discard the remainder.

The longer a beer is stored before drinking, the better the sediment stays on the bottom of the bottle. The sediment is not harmful to drink, in fact, it is extremely rich in B vitamins and iron.

This chapter only briefly describes the many processes involved in Wine and Beer making. For a thoroughly delightful and enlightening treatment of this subject, the reader is advised to read the book **Making Wine, Beer & Merry** published by Popular Topics Press, Box 1004, Fostoria, Ohio 44830.

CHAPTER 7:

Other Beverages



All it really does is make drip coffee.....but it looks so impressive people gladly pay \$12.00 a cup!!

This could easily be the largest chapter in the book — but it's not going to be. There are so many beverages — both alcoholic and otherwise — that we are going to need to sort through these and mention only those with some degree of popularity or uniqueness. To make it convenient for the reader we are going to compact this information by alphabetizing the beverage names followed by a brief description.

A breakdown of the different types of, say, wines, beers, gins, mixed drinks, etc. is included in the *Alcoholic Beverage Guide* in Chapter 9.

The drinks we shall discuss in this chapter each falls into a generalized category of its own. Some are alcoholic and some not, but somewhere in the world each one is considered a palatable, as well as potable, drink

All potable beverages consist of water plus additives. The additives determine the character of the drink. Not only the type of additive but how it is treated either before, during or after it is added. For instance, if you boil green coffee beans in water the drink will have little if any resemblance to a drink that uses the same beans toasted and coarsely ground.



Aperitif Do not confuse with aperitive which is a mild laxative. An aperitif is much like a liqueur, but it is not generally based on a distilled product as is a liqueur. Flavorings, etc. are added to a basic wine or fortified wine. Vermouth is the best example of an Aperitif.



Beer A fermented beverage that derives from the fermentation of a malted grain, such as corn, barley rice, etc. Usually the base used is wholly or mostly barley. The alcoholic content is given in both percent by volume and percent by weight – but usually the latter. There is a difference. The alcoholic content of beer by volume is in the range of 3 percent to 8 percent, with most about 4 or 5 percent. See table D in Chapter 9 for comparison with percentage by weight.



Cider Unfermented apple juice.



Coffee Coffee originated in the Arabian countries and then spread rapidly throughout the world. Most of the U.S. coffee is a direct descendent of a single coffee plant that was brought to the New World in 1723. It is a refreshing beverage which, like tea, owes its stimulating qualities to the presence of caffeine.

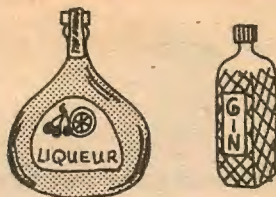


Cordial Sometimes used to mean a liqueur, this usage is incorrect. A cordial is merely an extracted fruit juice made into a syrup by adding sweets or rendering down. If it is not too thick or syrupy, it can be used as a sweet drink by itself. Cordials are used as basic flavor additives for other drinks. They can be made naturally from fruit products or artificially and are non-alcoholic by themselves.

Kephir Also Kefir. The same as Koumis, but usually started with cow's milk instead of camel or mare milk.



Koumis A mildly alcoholic beverage popular with northern Asiatic tribes. Contains about 2 percent alcohol and when distilled is called Arika. Normally lactose (milk sugar) is not fermentable. However, Koumis is made from Mare or Camel milk by the action of Lactase (an enzyme) which breaks lactose down to its simpler constituents glucose and galactose, both of which are fermentable.



Liqueur Note the spelling. Sometimes applied to a very few wines and distilled liquor of very high quality. This is not its common meaning, however. The typical liqueur starts with a basic distilled liquor. To this is added intense or unusual flavoring and perfumes. France was an innovator in this area and many of the most popular extracts used today are French. Some popular extracts are mint, angelica, sassafras, lemon, orange, peppermint, cinnamon, tea, coffee, etc. Many times artificial flavors, colors and edible perfumes are used.

Liquor An alcoholic beverage from about 50 to 190 proof, but usually no higher than 120 proof. Distilled from a mash or a wine, its main flavor is derived from the constituents of the basic mash from which it is distilled plus the slight "contaminants" introduced during aging from contact with a wooden barrel or other container, plus the actual chemical changes occurring during aging. Few or no direct additives are used in the distilled product. Whiskey, Vodka, and Gin are good examples.

Perry Unfermented pear juice.



Pop Wine Normal wine has its flavoring ingredients added before fermentation begins. If a neutral base, such as sugar and nutrients, is fermented out and THEN the flavoring added, the result is a Pop Wine. It is not appreciably different from an ordinary mixed drink such as a Tom Collins, Screwdriver, etc., depending on the fruit juice or flavor added.



Spirit Sometimes used to denote either pure alcohol or the alcoholic portion of a liquor. More generally, Spirit is used in the same sense as liquor, and the two are used interchangeably.

Syrup See Cordial



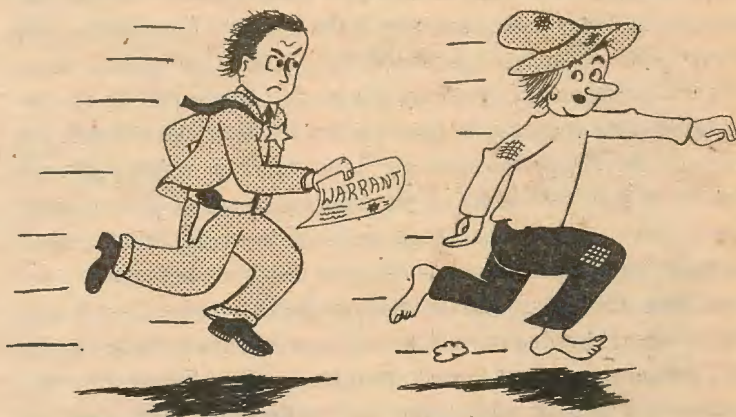
Tea Tea throughout the world comes from the same basic plant. Differences in tea names, such as orange, orange pekoe, black, green, etc. come about from using different processing. Black tea is processed by fermentation. Green tea is unfermented. The bulk of the world's tea is grown in the Asiatic countries such as Ceylon and India. It owes its popularity to the presence of a chemical class of compounds, caffeines, which are stimulants.



Wine A fermented beverage using any grain, fruit or cereal as its base. If it is not made from grapes the word Wine should be qualified with an adjective such as Apple Wine, Blackberry Wine, etc. If no adjective appears, it is commonly understood to be Grape Wine. The alcoholic content is given in percent terms and is usually in the range of 10 to 21 percent by volume.

CHAPTER 8:

Lores & Legends



"Why hello there! Do you jog for your health too??"

Almost every activity of leisure human endeavor, save perhaps eating and sleeping, is in some manner regulated, legislated, or moralized against. Sex, alcoholic indulgence, dancing, card-playing, gambling, theatre attending and even just plain conversation or quiet reading have all had their doomsayers and attackers. Our concern in this book is only with Ethanol and its production. There are quite enough tales of the chased and the chastened in this narrow area to fill a few volumes — and indeed more than several have been written.

MOONSHINERS

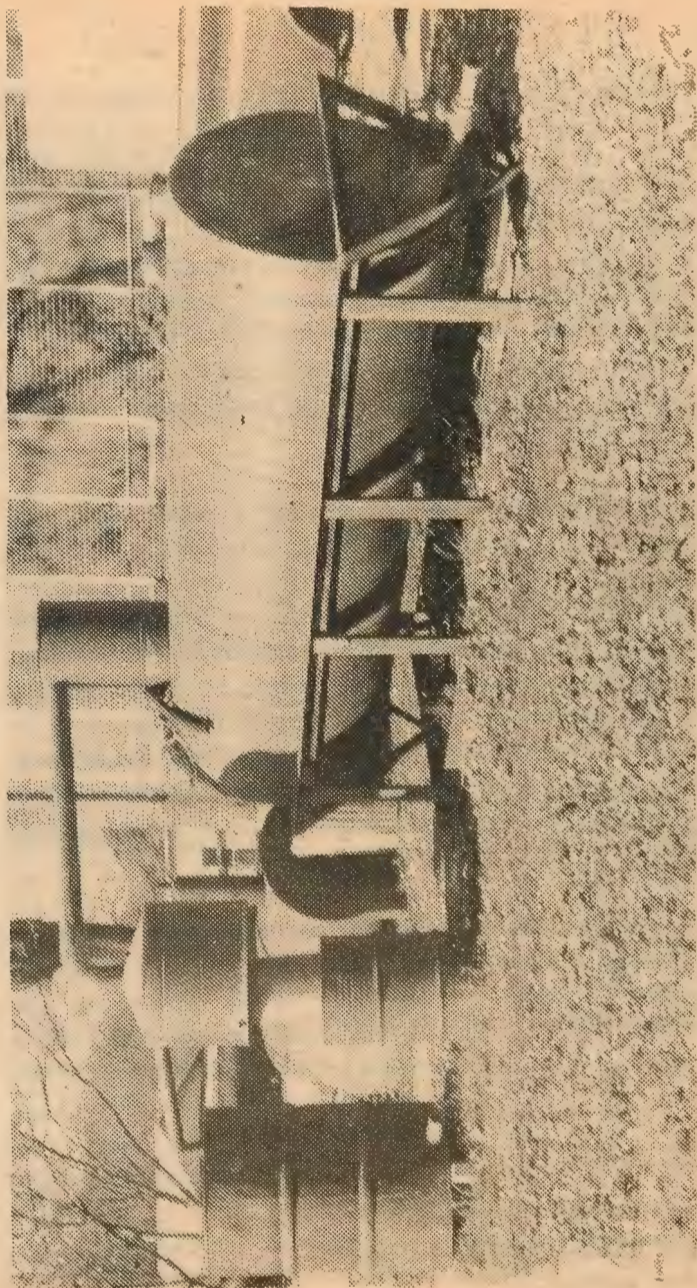
It is hard to say where the word moonshine originated. Every source has its own theory, but the name is descriptive enough of the secretive nature of the operation. There are those that make and sell illegal

liquor (moonshiners, bootleggers, etc.) and those who chase them (sheriffs, BATF agents, etc.).

The Bureau of ALCOHOL, TOBACCO & FIREARMS is charged with enforcing the liquor laws, as an arm of the Treasury Department. The present Chief of the BATF, at this writing, is Mr. Rex Davis, a charming and personable professional. His interest is in enforcing the law as it affects the collection of taxes by the Treasury Department. According to Mr. Davis "moonshining" is not nearly so widespread as it once was and for most practical purposes can be said to be well under control. It is essentially one of those problems that helps to solve itself. The basic ingredients are not as cheap as they once were, people are more affluent nowadays and the taxes on alcohol have not risen in step with inflation. Thus the enormous profit margins are no longer there. Mr. Davis also surprised us with the myth-breaking information that the historical areas of moonshining such as Kentucky, Tennessee and W. Virginia are no longer producers of any great amounts. If there is any concentration worthy of the name it is on the middle and lower atlantic seaboard around the Carolinas.

But in days not long gone the activity was aplenty. Especially during downturns in the economy, such as the Great Depression. It is also true that when an area votes itself "dry" (such as many do under the local option plans) then moonshining activities increase enormously in that area.

Some of the early and surprising aspects of moonshining were the ground rules that slowly grew up. During the late 1800's and early 1900's it was not unusual for an arrest at a still site to be a deadly confrontation between two armed groups: the federals and the moonshiners. As could be expected fatalities were often heavy on both sides. Also, as could be expected, the Federal Government with infinitely greater resources at its command, was not going to take the shooting of its agents lightly. Harsh prison sentences were handed down when such shooting occurred.



Large still impounded during a "moonshine" raid in Oklahoma

During this period a group of clergymen who were friendly with both sides in the combat got together and helped bring about a decline in the warfare. The moonshiners didn't stop distilling and the feds didn't stop looking for them. But the clergymen made the point to the moonshiners that the Feds weren't going to prosecute anybody if they couldn't find anybody at the still. Since they were going to lose their still if the Agents found them, no matter what, both sides would be better off alive than dead. After this period a new tactic on the part of the moonshiners gradually evolved. When they were busted they ran like a streak of lightning. Presuming they could outrun the Agents, that was the end of it usually.

But of course every new weapon is met with a counter-weapon. The tale is told of a moonshiner named Charlie Potts that was found dead -to-rights with his still cooker burning brightly. Charlie took one look at the agents and took off through the woods. One of the Agents in the raiders, nick-named Big-six, had been an outstanding college athlete and couldn't resist the challenge and the chase. Big-six took off after Charlie and chased him up and down through the fields, over the fences and down every byway known to Charlie Potts. Big-six finally caught up with Charlie and collared him, but they both collapsed from exhaustion after the capture. And no wonder. His fellow agents found that Big-six and Charlie had run at least two miles!

More recently a case in California reads almost like a Keystone Kops comedy. A Federal Agent gained the confidence of several bootleggers and posed as a big buyer for the underground. The moonshiners sold him a small amount of alcohol and he went on his way. However, after a discrete wait of a few days, other agents moved in and arrested the bootleggers. The trapped bootleggers still were not aware that the original "underworld character" that bought from them was a Federal Agent. So while they were awaiting sentencing to prison the first agent contacted them, still posing as an underworld buyer, and asked to do business with them when their prison sentences were up. They both readily agreed. After they were released the Agent set up productions schedules with them and helped them get their still

going, even to the point of buying them a ton of sugar with government vouchers. When all was finally going good and the still was producing successfully, the Agent stepped in and SURPRISE arrested them all. Imagine their shock. However this second arrest did not hold up in court. It was thrown out because the agent had used ENTRAPMENT. Essentially the statutes on entrapment say that you can arrest a man for breaking the law but you can't encourage or help him to break the law and then arrest him!

Almost every conceivable reason is used by moonshiners to excuse their conduct. In a recent case in Ohio a moonshiner claimed that his wife was an alcoholic and he couldn't afford to keep her in spirits. He went to jail and she, presumably, started paying more for her habit. Others have claimed that they were only walking by and saw the still just before the agents arrived! It was a common practice of some of the more unscrupulous operators to find a young relative to act as a helper. Then when a bust occurred the youngster would claim the still was his and get off on probation or, at worst, with a very light sentence.

Once arrested for distilling alcohol your troubles are hardly over with your prison sentence. For almost any other crime imaginable including murder, rape, assault, riot or mayhem, the case would stop with your sentencing. But if you are caught distilling in your garage or basement you go to prison AND you lose your home, your car and all of your possessions that are anywhere located on these premises. They will all be sold at public auction.

It is one of those incredible and bizarre overkill laws that occur whenever the enormous power to totally annihilate or confiscate is concentrated in a governing body and used irresponsibly. It is unworthy of the dignity of the government we all are so justifiably proud of.

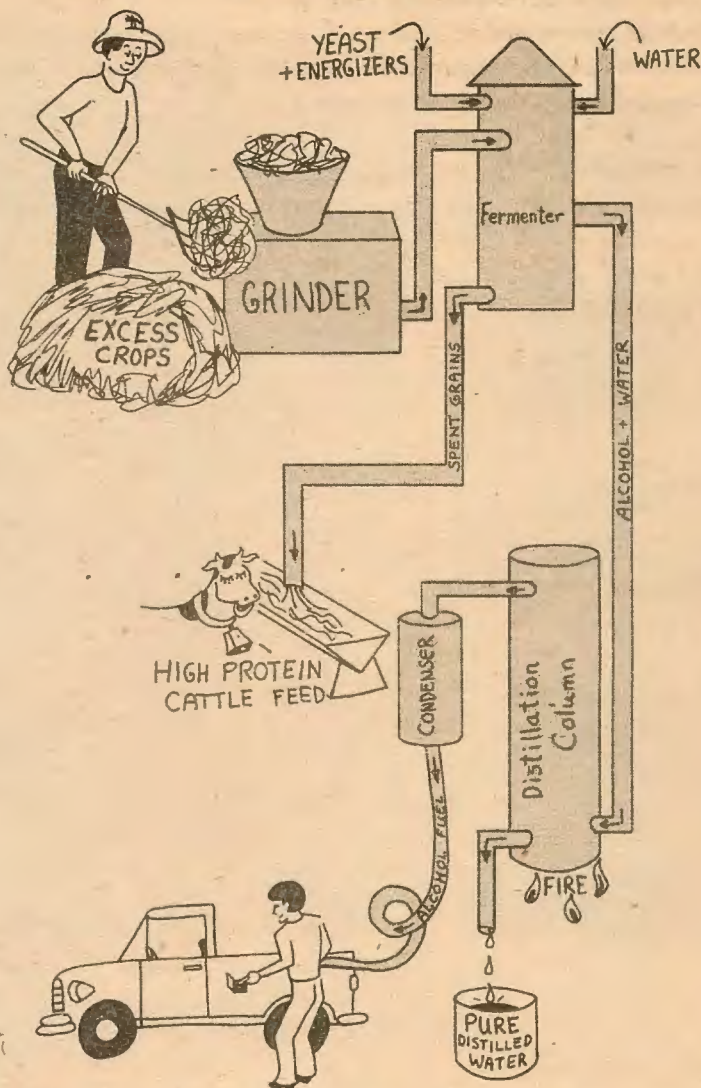
Too many times the agents of the BATF are blamed for some of the more unsavory statutes that they are responsible for enforcing. It is

the legislature that makes the laws and batteries of high-priced consultant lawyers and political appointees that write the statutes. If the tax laws were not enforced the inequality that now exists in how the tax load is shared would be even worse.

It is unfortunate that the legislature has decided to invade the private household and forbid you to distill for your own private usage. As we have commented before, this is NOT true of tobacco and other items which are also taxed. But changing this condition will be up to the legislature and that is where the battle will need to be fought.

PART II

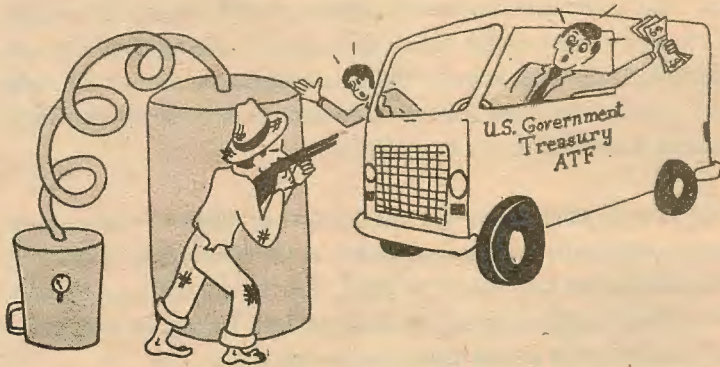
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**How to Produce Fermented
& Distilled Fuels**

CHAPTER 9

Gasohol & Ethanol



NO! WAIT! STOP! We don't want to BUST it.

We want to BUY it!

GASOHOL

It surprises most of us to learn that **GASOHOL** is nothing new. It was first conceived over 50 years ago. During the depression days many books, pamphlets and University Research papers were written on the subject. It was well explored and widely publicised (for the times). Then why are we only now in a panic to develop it? Ah, thereby hangs a tale by the tail!

One of the aspects of free democracies (as presently developed) is they operate primarily from crisis to crisis. In this we can't blame the other fellow; we can't blame the oil interests; we can't blame the government; and we can't blame the auto companies. It is us! You and me. And countless others (well, actually a little over 200 million) just like us. We will not spend 6 hours, say, growing grain and fermenting it when we can spend two hours drilling a hole in the ground for the same end result: fuel. No arguments about future generations will ever sway present generations when it actually comes down to doing the

work. The numbers we are using are made up but the principle involved is not. We are now at the point where it is about 6 hours work either way. If this change in value had occurred over a span of forty or fifty years, it still would not prompt us to change our methods since we even resist "change" itself. You and me, remember? Not the "other guy". But the change has been so catastrophically rapid – only a few short years – that even the dullest amongst us has caught on. Perhaps alcohol isn't the final answer. But it is a workable answer for right now. Until we can either perfect its production or come up with some superior alternatives, it can do the job.

We have no solutions for the much bigger problem of why we, as a nation, continually paint ourselves into economic corners. Perhaps it is the fault of the institutions we build to serve us. Ask your friendly corner Political Scientist or Economic Adviser. He can be working on that problem while we are trying to solve this one.

Prior to World War II, many European countries were requiring the use of GASOHOL to conserve dwindling supplies of petroleum. In 1931 the Phillipines sold a blend of gasoline, alcohol and ethyl ether. They called it GASONOL and special motors were designed to burn it efficiently. In the early 1930's Germany mandated a 10 percent alcohol, 90 percent gasoline blend – exactly the same blend advocated so widely even yet. The first large undertaking in the United States was also to produce a 10-90 mix. This was in Atchison, Kansas during 1934. The operation failed before the start of World War II. It nearly succeeded, however, in spite of a number of disadvantages. They called the mixture AGROL for AGRicultural alcohOL. It represented one of the many early attempts by farmers to exert some control over the product of their labors.

It is difficult to determine just who coined the term GASOHOL for the first time. GASOHOL is defined as a mixture of gasoline and alcohol. The alcohol can be Ethanol (Grain Alcohol) or Methanol (Wood Alcohol), or even higher alcohols (see Table II). Ethanol is readily produced from easily fermentable materials and, at present, this is the alcohol usually blended to produce GASOHOL. We have

TABLE I
Properties of Aliphatic Hydrocarbons Found in Petroleum and Natural Gas

This chart is for the normal isomer

This table is similar to the one in Chapter 3 but includes more useful data.

Formula	Chemical Name	Physical State	Boiling Point F°	Common Name	Percent From Crude Oil Fractionation
CH ₄	Methane	Gas	-258	Natural Gas	23
C ₂ H ₆	Ethane	Gas	-126.4		
C ₃ H ₈	Propane	Gas	-51		
C ₄ H ₁₀	Butane	Gas	30.2		
C ₅ H ₁₂	Pentane	Liquid	96.8	High-grade naphtha	
C ₆ H ₁₄	Hexane	Liquid	156	Gasoline	
C ₇ H ₁₆	Heptane	Liquid	208		
C ₈ H ₁₈	Octane	Liquid	259		
C ₉ H ₂₀	Nonane	Liquid	302		
C ₁₀ H ₂₂	Decane	Liquid	345		
C ₁₁ H ₂₄	Undecane	Liquid	383		14
C ₁₂ H ₂₆	Dodecane	Liquid	419	Kerosene	44
C ₁₃ H ₂₈	Tridecane	Liquid	453	Fuel Oil	
C ₁₄ H ₃₀	Tetradecane	Liquid	487	Lubricating oil mixtures of higher hydrocarbons	
C ₁₅ H ₃₂	Pentadecane	Liquid	520		13
C ₂₀ H ₄₂	Eicosane	Solid	amorphous	Paraffin	3
C ₃₀ H ₆₂	Hexecontane	Solid	amorphous		
					Remaining 3 percent is lost

NOTE: These approximate fractions are from a simple fractionating column. By the use of catalysts and specialized processes, more than 50 percent of the crude can be converted to gasoline if this is desired. Or, conversely, less can be converted.

discussed the production of Ethanol in Chapter 4 (fermentation) and the concentration of Ethanol in Chapter 5 (distillation). We will now explore the additional things we need to be aware of for Ethanol production as a gasoline additive and as a fuel to be used by itself.

GASOHOL is by nature a stopgap. It is not an ultimate solution to any problem. ALCOHOL, by itself, may be an ultimate solution, but at this writing it has yet to be proven. GASOHOL is not an ultimate solution because it is a mixture of a non-replenishable resource (gasoline) with a replenishable resource (alcohol). Even worse, the mixture usually has much much more of the non-replenishable resource (90 percent). When petroleum supplies become very scarce or dry up entirely, which they are bound to do, GASOHOL will be over and done with. But for the present it does extend out our supplies by 10 percent which is important.

Gasoline is not a single compound, such as Ethanol or Methanol, but is a mixture of many compounds. Alcohol and gasoline have different vapor pressures (ability to evaporate). Many of the constituents of gasoline actually boil at temperatures not much above room level. This is especially true of gasoline blended for winter time usage. Refineries adjust their mix or blend to correspond to the seasons. In winter the blend has more of the lighter hydrocarbons in the naptha range. See Table I for a comparison of the hydrocarbon products resulting from the distilling or cracking of petroleum. Table I lists the typical products that result from the simple fractional distillation of petroleum oil in a refinery. See pages 68-69 for a description. The compounds at the top of the table are the first to evaporate. The further down the list you go the further up the fractionating column the product comes off. During the summer the blend is again changed. The naphthas are dropped and more of the higher boiling products are included. In the fall and spring a compromise blend is produced.

TABLE II lists the simple alcohols in the same ascending order of complexity and density as Table I does for simple petroleum products. These tables are the same as Tables I and II in chapter 3, but contain more detail. A reference to these tables now and then while reading

TABLE II
Properties of Simple Alcohols
 This chart is for the normal Isomer

ALCOHOL	FORMULA	PHYSICAL STATE ★	BOILING POINT °F	FREEZING POINT °F	SOLUBILITY IN WATER
Methyl Methanol	CH ₃ OH	Liquid	149	-144	Yes
Ethyl Ethanol	C ₂ H ₅ OH	Liquid	172.4	-179	Yes
Propyl etc.	C ₃ H ₇ OH	Liquid	208	-197	Yes
Butyl	C ₄ H ₉ OH	Liquid	244	-128	about 10
Pentyl	C ₅ H ₁₁ OH	Liquid	280	-108	a few
Hexyl	C ₆ H ₁₃ OH	Liquid	313	-62	slight
Dodecyl	C ₁₂ H ₂₅ OH		491	73	insoluble

This table is similar to the one in Chapter 3 but includes more useful data.

★ Physical State at 68

this chapter may help your understanding – if not your enjoyment.

What are some of the advantages and disadvantages of 10 percent mixtures of GASOHOL? A 10 percent mixture has one overriding advantage. You don't notice the difference between burning a 10 percent mixture and burning pure gasoline. No adjustments to your carburetor or motor need be made. The driving characteristics such as pick-up, stall, etc. will not be altered enough to be noticeable. This is a big advantage during a transition period when millions, perhaps billions, of motors (car, boat, tractor, cycle, mower, power plant, truck, train, etc., etc.) are already produced and designed for gasoline or diesel use. The cost of converting these all to a different fuel would be prohibitive – even if it could be done which it can't!

GASOHOL & WATER

It is reliably reported that the 10 percent ethanol in GASOHOL actually improves the burning of the gasoline. A cleaner exhaust may result. Water in a gasohol mixture can be very disturbing, however. When pure ethanol and gasoline are mixed, the ethanol has practically no contact with the air (it is only 10 percent of the solution and is surrounded by gasoline molecules). Therefore it does not tend to draw water from the air. But if water gets into the tank by condensation or otherwise, the water acts as an entraining agent for the Ethanol (makes it separate from the gasoline). A surprisingly small amount of water – even as little as 1 or 2 percent can entrain (or capture) all of the ethanol. The problem here is not that the ethanol won't burn with this slight amount of water in it. Rather, the problem is the ethanol is no longer evenly disbursed throughout the gasoline. It is concentrated in a pocket and when this pocket of nearly pure ethanol hits your fuel intake line it goes through a carburetor that is adjusted for gasoline (gasohol) and not adjusted for pure ethanol. The mixture is too lean as alcohol needs an air to fuel ratio of 9:1 (10 percent alcohol)* and not

* Compute these percentages by dividing the amount of air by the total amount of gas. This is $1/(9+1) = 1/10$ and not $1/9$. Actually, the 14.5:1 figure is for pure gasoline. As it turns out the addition of ethanol to the gasoline in producing gasohol makes the fuel-air mixture more tolerant. That is, it is not as critical as it was for pure gasoline. Another added advantage of gasohol. The engine is easier to tune and keep in tune.

14.5:1 (6 percent gasoline) as does gasoline. Therefore the motor misses, sputters and coughs.

10 percent GASOHOL buys time. Time for planning. Time for experimentation. Time for learning. Time for the more painful psychological readjustments for you and me. Life will not be harsher or less fun after we develop new and different fuels and adjust to them. It will be different. But to imagine that we are going backward in time is folly. We are simply taking steps now that could and should have been taken by our ancestors a few short generations back. But before we pat ourselves on the back for our own great foresight consider two things:

1. We were forced into it ourselves, as a society, even though we were fully aware it was coming and even knew when.

2. Future generations are going to lament this generations inability to come to grips with a whole panoply of similar problems that are even now staring us all in the face and each problem will come to a crisis stage in its own time – just like this one – before anything is done about it.

Discouraging? Not at all. Human nature. And “Human nature” can and does change. But the change is so slow, and our 70 to 100 year life span is so short in the scheme of things, that we can’t even discern it. Write a note to your great-great-great-great-grandkids. Ask them how much change – really basic change – they see since your day. By then it should be discernible. Just barely, but still discernible.

ABSOLUTE ALCOHOL

Now let us go the the other extreme and consider pure or nearly pure alcohol. Prior to this time we have used the proof concept for Ethanol as a carryover from the beverage alcohol discussion. From this point forward we will consider percentages. The proof concept is an artificial concept and has no real value. It certainly has no place in a technical discussion.

Pure Ethanol is difficult to produce from the fermentation

-distillation process. This was discussed on pages 31-34. To obtain purity much beyond about 95 percent, such things as benzene or lime (CaO) must be added and then the product redistilled. 100 percent Ethanol is called Absolute Alcohol.

It is to be noted that fermentation is not the only way to produce Ethanol. Early in this century chemists perfected a way to produce High quality Ethanol from Ethylene. Ethylene is one of the common byproducts of fractional distillation of petroleum when making gasoline. Although this method has been used to produce as much as 60 percent of this nation's Ethanol in the past, it is, to us today, a dead-end process. This is because the source of Ethylene is the very same source we are striving so hard to be independent of: petroleum.

Absolute Alcohol is anhydrous and hygroscopic. That should send you to cover the children's ears. Anhydrous simply means that it is a compound that has had all of its water removed. Hygroscopic means that it wants it back! So if you open up a container of Absolute Alcohol, the alcohol will actually soak up some humidity from the air itself. From this you can see it would be useless to go to all the bother of using entrainers and re-distillations to produce absolute alcohol for fuel purposes because as soon as you put it in your fuel tank it would zap some moisture right back out of the air. It wouldn't keep this up indefinitely of course. Actually it would absorb only a small amount. But that is enough to destroy its character of Absolute Alcohol.

Since alcohol was at one time used widely in car radiators to prevent freezing in the winter, it is apparent that water and some alcohols do mix thoroughly (miscible is the technical word for the complete mixing of two liquids) and that a mixture of alcohol and water has a much lower freezing point than pure water. See table II for the solubility of alcohols. Thus a tankful of alcohol (Ethanol) with a few percent of water in it would act very nearly as pure Ethanol, which Table II gives a freezing point of -179 degrees F. No danger of freezing and it will burn just about as great as 100 percent Ethanol.

A few percent water in gasoline would be disturbing since gasoline

and water do not mix in any proportions normally. Thus in the winter time frozen fuel lines can occur. In the summer the engine would sputter and miss.

ETHANOL & WATER

How well will Ethanol and water burn as a fuel? That depends on the amount of water. But for rather large amounts of water it won't hurt a thing. Concentrations of 50 percent water and 50 percent alcohol have been used satisfactorily. This is about the bottom limit. It is interesting that one early investigator recommends this 50-50 ratio to be used in a specially designed engine to produce a pseudo steam-engine. His analysis was that the half alcohol would burn and turn the half water into live steam which would then help move the piston. Who knows, it might even work!

For a variety of reasons, it is best to use higher concentrations of alcohol. 90 to 95 percent or practically pure alcohol will undoubtedly prove out best. For one thing if you are using a low concentration of alcohol, say 60 percent for instance, you are going to be cutting down the gross mileage you get out of a tank of fuel by 40 percent, which is a big number. A 20 gallon tank of 60 percent Ethanol will really have only 12 gallons of useable fuel. The other 8 gallons is water which is excess baggage since it does little or nothing to improve the car's performance or mileage. It actually adds about 64 lbs. of deadweight. So if you were getting 20 miles to the gallon of pure ethanol you would have only a range of about 240 miles per tank of fuel instead of 400 miles. Even with 90 percent ethanol you are carrying two gallons of water around in your full 20 gallon tank. Besides this the excess water makes it increasingly difficult to start your motor. Alcohol starts harder than gasoline at best. Remember that with gasoline the refiner can and does add more volatile (easy to evaporate) components in the winter. This makes it easier to start. Ethanol is a single compound not an admixture, as is gasoline. It has but one single boiling point (173 degrees F) and that is relatively high. About the only real argument for using wetter ethanol than 95 percent is if the still design you have is at its most efficient at some lower value. But even then it is

TABLE III

Approximate amount of Heat in a few common fuels

SOLIDS	BTU's per LB
Wood	7250
Charcoal	13,500
Peat (dried)	7500
Coal	13,000

LIQUIDS	BTU's per LB
Gasoline	18,500
Kerosene	
Ethanol	12,000

GASES	BTU's per CU. FOOT
Methanol (natural gas)	1100 drilled from wells as is oil
Coal Gas (methanol, hydrogen)	500 made by heating coal in air-tight environment
Water gas & Producer Gas (hydrogen, carbon monoxide)	250 made by passing steam over hot coal.

One BTU (British Thermal Unit) is the amount of heat required to raise the temperature of one pound of water one degree Fahrenheit.

not advisable to go below about 75 percent.

One method of making it easier to start an Ethanol powered motor is to preheat the carburetor air before running it into the cylinders. This can be done best electrically and need only be done just prior to starting the motor or while cranking it.

ETHANOL AS A FUEL

Ethanol has some real advantages as a fuel. It has some real

disadvantages. But after we run through a quick comparison, it should be easy to see that they about balance out – which means that once the dust settles on the research and development, ethanol will be every bit as good as gasoline right across the board. Where there is a disadvantage in one area, there is an equal and compensating advantage in another. The real question seems to lie in the area of whether it can be made available in sufficient quantities and at a low enough price.

OCTANE

The octane rating of ethanol is about 100 using the common pump method now widely accepted (by fiat)* in the U.S. Regular gasoline with a lead additive is about 90. Lead-free blended gas is a little less yet. Thus alcohol can be used with spark engines (common automobile and small tractors) having higher compression ratios than possible with regular gas. It is also a good diesel fuel but some lubricant must be added to it for most diesel engines or you will burn out the fuel injection pump (which was normally lubricated by the oily diesel fuel). This latter problem with diesels is strictly an engineering problem. In other words a redesign can readily solve it for ethanol burning diesels. Water with the ethanol seems to help the octane rating even more. But probably not enough to compensate for its large disadvantages.

Why is octane rating important? Because Horsepower is. Here is a common formula for horsepower for a single cylinder of a multiple cylinder engine:

$$\text{HORSEPOWER} = \frac{\text{PLAN}}{66000}$$

P - Pressure in cylinder at explosion

L - Length of the stroke

A - Area of cylinder

N - Number of power strokes per minute

* No, not the auto company!!

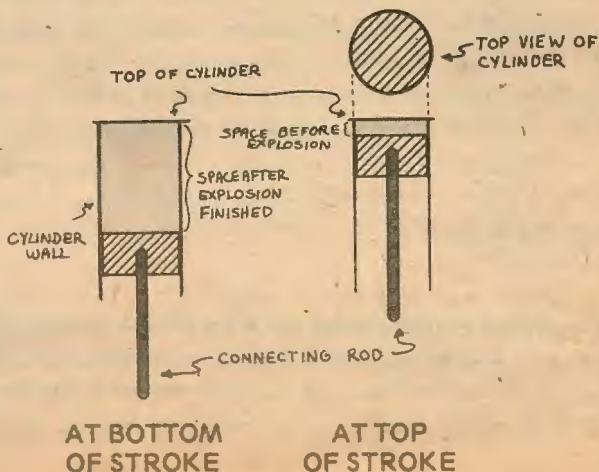
In other words, if you multiply P times L times A times N and then divide this result by 66000 you will get the horsepower of each cylinder of a multiple cylinder engine. Notice that any time you multiply something by a larger number you get a larger result. Thus if we can increase the size of any of the factors P, L, A or N we can directly increase the horsepower of the engine. Increasing L or A simply increases the size of the engine. So if we are trying to get as much horsepower out of as small an engine as possible, we won't even consider this method. N, the number of power strokes per minute can be increased somewhat but there are sharp physical limits beyond which the engine merely throws itself to pieces, which is no fun at all. This leaves us only the pressure, P. The pressure can be increased by using different fuels and by squeezing the fuel mixture more before exploding it. We are limited in the fuel we can use to what is readily and easily available in wide distribution. So we are left with squeezing the fuel and air mixture more before exploding it. Figure 1 shows what we mean by the compression ratio. When the piston is at the bottom of its stroke, the empty space above it is at its largest. When the piston is at the top of its stroke, the empty space is smallest. The ratio (dividing the larger by the smaller) of these two spaces is the compression ratio. For instance if the piston traveled down the cylinder 6 inches on the downward stroke and came up to within 1 inch of the top on its upward stroke, then the exploding gases can expand to 6 times their original volume before being expended from the cylinder. Thus the cylinder has a compression ratio of 6 divided by 1 ($6/1$) or as it is more commonly written 6:1 or simply stated as "6 to 1". Early engines had compression ratios of 4 and 5 to 1. Modern engines commonly have ratios of 7 or 8 to 1 or thereabouts. In an actual engine it is not as easy to compute the compression ratio because the cylinder head is not perfectly flat and smooth as we have shown in our simplified diagram. But the principle is the same.

The reason older cars did not have higher compressions was not that engineers in 1920 did not know about our formula above. They knew it very well. But low grade gasoline "knocks" or pings at compression ratios higher than 4 or 5 to 1. This is because for smooth power transfer the flame in an exploding cylinder should move

smoothly and regularly outward from the spark plug when it is ignited. When a gasoline knocks it indicates that some "detonation" is taking place elsewhere at another place on the cylinder head. This simply means that squeezing the gas so much more tightly in a higher compression engine heats the gas higher and some of it tends to spontaneously combust with or without the spark plug. Now instead of a smooth flame front, two or more separate explosions occur and cause the piston to be knocked sharply to one side or the other (ever so little but still enough so you can hear it "knock" on the cylinder wall). This wastes power and is hard on the engine. Both undesirable. After experimentation it was found that certain of the constituents of gasoline (see Table I) resisted this tendency to pre-ignite more than others. The best of the lot was OCTANE so it is used as a standard for anti-knock ability. Octane was arbitrarily given a value of 100 and all other gasolines and compounds compared to it as less than 100 (poorer) or more than 100 (better). Tetraethyl lead was found to help increase the octane rating of gasoline during the early 1930's and is still used in our "regular" gasolines. Ethylene debromide is another

Figure 1
Compression Ratio

Diagram greatly simplified. No valves, spark plugs, etc. have been shown



additive that increases octane rating. Combinations of these and other additives are used in what used to be called the "ethyl" or "high-test" gasoline. But even these additives have their limitations. To increase the compression ratio much above what is presently used the best solution is to go to diesel where the octane rating of the fuel is immaterial. It is not forced into the cylinder until AFTER the cylinder is at or near the top of its compression stroke. Consequently compression ratios double those used in gasoline engines (16:1 and higher) can be and are used.

DIESELS

At this writing it appears that Ethanol, methanol or some similar replenishable fuel will ultimately come into universal service and the engine used will be the diesel. The diesel must be heavier built to withstand the extreme pressures it generates (over 500 lbs. pressure per square inch and 1000 degrees F. temperature at the top of the stroke before ignition) but it is one of the most efficient engines ever built. The science of metallurgy has advanced to the point that relatively light-weight, but strong, diesels can now be built. But it is still a question of cost. Also, the diesel performs a little poorer than the gasoline engine at lower speeds and under varying speed conditions. These problems are not large. Interestingly enough the diesel engine always takes in the same amount of air on each stroke (contrasted to the adjustable flow of the gasoline engine) so the power of the stroke is varied by varying the amount of fuel inserted. Thus the air to fuel mixture in a diesel can vary from 20:1 or so up to 80:1 or more. In a gasoline engine it is held steady at about 14.5:1, regardless of speed or load conditions. Rudolph Diesel, who invented and developed the diesel in the 1890's, fell overboard in the English Channel and drowned in 1913, at the age of 55.

Thus while the octane rating of 100 for ethanol is important when dealing with spark-plug ignited engines (commonly called gasoline engines) it can be seen that it will be of little import if diesels evolve as the most fit of the species. And Darwin has already told us what

happens to the unfit.

The hard-starting features of ethanol will also be solved by switching to Diesels. All Diesels are hard to start. Let's see, did we really solve that one or did we just do a fast shuffle?

VAPOR LOCK

We mentioned that hard starting is generally caused by the higher boiling point of ethanol (173 degrees F.). This higher boiling point does have some advantages. Vapor Lock is caused by gasoline turning into vapor (gas) before it is supposed to do so (in the carburetor and intake manifold). The fuel pump and associated system in a vehicle is designed to pump a liquid and not a gas. When the vapor comes along into the pump it can wreak havoc with the pumping action. It either stops the action altogether if it is a large bubble of vapor, in which case the vehicle stops dead too. Or, more commonly, smaller bubbles cause the vehicle motor to miss while the fuel pump is trying to disgorge those awful bubbles. Vapor locks usually occur in the hot summer time or if a vehicle has a poorly designed gas line system that routes the line too close to a hot exhaust manifold or muffler system. Ethanol is not prone to vapor locks.

ETHANOL & POLLUTION

Now we can discuss some very large advantages indeed. First, Ethanol burns cleanly. It carries along some of its own oxygen supply (much like gunpowder which does not need any oxygen from the air). For this and other reasons rockets often are designed using liquid oxygen and an alcohol fuel. Only half as much oxygen is needed as would be needed for petroleum products. This saves weight and weight is all-important to a rocket's performance. But the benefit to us is clean burning. Alcohol burns easily and completely.

The primary exhaust products coming out of a vehicle using Ethanol fuel are carbon dioxide and water. If these are polluting then we and the entire plant kingdom are in real trouble. There may be other trace

products caused by impurities or incomplete combustion. These are few in number and small in quantity.

Ethanol also is an excellent solvent for many lacquers, gums and resins. Gasoline engines deposit resins in the carburetor and elsewhere through the fuel system. Their carburetors need to be cleaned of this occasionally. Gasoline also coats the inside of the engine with heavy deposits of carbon and other burned byproducts. Ethanol does none of the above. In fact it actually cleans up a car that has been running on gasoline. Ethanol even cleans up rust from fuel and tank lines. There is a note of caution here. The paint on most vehicles is a lacquer base (some "natural" and some synthetic) paint which may be dissolved by Ethanol. More precautions in filling your fuel tank are in order if you wish to protect your shiny new finish.

One of the worst – if not THE worst – pollutant in gasoline is sulfur dioxide. There is no sulfur dioxide effluent from an ethanol fueled engine.

Absolute alcohol (100 percent Ethanol) has no corrosive properties. However the commoner 95 percent mixture is slightly corrosive on lead and aluminum. The use of aluminum blocks in Ethanol motors may need some study. Probably a proper alloy of aluminum can be made. On the other hand, the corrosive action may be small enough as to be negligible over the life of the motor.

ENERGY & EFFICIENCY

The amount of heat generated by a fuel is measured in BTU's or British Thermal Units. One BTU is the amount of heat required to raise the temperature of one pound of water (16 oz.) one degree Fahrenheit (when the water is at or near its point of maximum density – which is 39.1 degrees F.). In other words if ten pounds of water are raised in temperature by one degree F., then it took 10 BTU's to do this. Conversely, 10 BTU's will raise the temperature of one pound of water by 10 degrees F. For our purposes we can ignore the restriction on measuring BTU's given above in the parenthesis after the

definition.



Gasoline will produce about 18,500 BTU's per pound (NOT gallon) when burned as compared to 12,000 for Ethanol. (See Table III). This is about 35 percent less or, to put it another way, only 65 percent as much heating value. Since heating value is energy, this would appear to show that alcohol has appreciably less energy. But we aren't through pulling rabbits out of our hat yet! The heat value does no one any good if you can't use it. A gasoline burning motor is able to efficiently utilize only about 25 percent of the energy available in the gasoline. No need to go into why here since gasoline is a fast fading fuel anyhow*. If you think that is poor efficiency, pity the poor steam engine. 10 percent is not bad for the efficiency of a typical steam engine. (90 percent of the input energy is wasted in discarded heat). Ethanol, on the other hand, has a thermal efficiency of about 35 percent. Gasohol, by the way, is about 28 percent. Thus the thermal efficiency of Ethanol in a properly designed motor is 1.4 (or 140 percent) times as great as gasoline ($.35 / .25 = 1.4$). If we multiply the BTU content of both gasoline and ethanol by their respective thermal efficiencies we get their approximate effective heat values.

$$\text{for gasoline: } .25 \times 18,500 = 4625$$

$$\text{for ethanol } .35 \times 12,000 = 4200$$

$$4625 / 4200 = .9081 \text{ or about } 91 \text{ percent}$$

* Besides, there isn't enough space in this book to cover the subject of thermodynamics in the depth and detail needed.

Thus ethanol comes within about 91 percent of gasoline as far as power output per pound is concerned. That is close enough to be quite comfortable. These figures all need to be taken as representative only, however. The BTU's in ethanol can be rigorously determined since it is a single well-defined substance (ignoring isomers). Gasoline is a mixture of many compounds and its BTU value is not a single constant and depends on the time and place of measurement. Common values are all close to each other but there is a variation in this value. Further, the efficiency of motors is a very large variable – as one would expect with all of the multifarious designs now extant. But the general conclusions we have reached here are valid: the thermal efficiency of ethanol is greater than gasoline and this helps to make up for the deficiency of BTU's in ethanol.

The diesel engine, by the way, has an efficiency of greater than 40 percent when burning diesel or fuel oil (petroleum products). Burning ethanol will not appreciably change this efficiency as it does with the gasoline engine. But if 35 percent is better than 25 percent, then certainly 40 percent rates something more than an honorable mention.

CARBON MONOXIDE

From an immediate safety point of view, the emission of carbon monoxide is of great concern. A gasoline engine can easily produce anywhere from 5 to 10 percent carbon monoxide (CO) which is, of course, toxic to animal life. With Ethanol fuel carbon monoxide is normally not a problem at all. Trace amounts only (far less than one percent) should be the worst expected. The haemoglobin in the blood (red blood cells) forms a loose association with the oxygen in the lungs and then acts as the carrier for this oxygen throughout the system. The haemoglobin combines with carbon monoxide over 300 times as easily, and furthermore, combines permanently. Oxygen, by contrast, is not strongly attached and is very easily given up so it can drop off the train, so to speak, when it arrives at its destination: the cells distributed throughout the body. When both carbon monoxide and oxygen are present, the carbon monoxide is 300 times more likely to be

assimilated. And worse yet, once combined the red blood cell cannot be used for oxygen transference any more. Needless to say, if there is much carbon monoxide present the body soon becomes overburdened by the useless red blood cells and the cells of the body start to asphyxiate from oxygen starvation. Death results rapidly if the concentration in the air is very great at all. If, on the other hand, the concentration is not very great and is removed shortly, the body quickly disposes of the neutralized red blood cells and replaces them with new active ones.

SAFETY

A decidedly large plus for ethanol is that it is safer to handle and store than gasoline. The flash point of gasoline (page 41) is about -50 degrees F and for ethanol is a little over +50 degrees F. Over 100 degrees difference in flash points (-50 to +50) indicates a huge safety margin for ethanol.

VEHICLE ALTERATIONS

A classic example that is often used to "Prove" the feasibility of alcohol fuels is the Indianapolis 500 mile race held on Memorial Day each year. All of these cars burn pure alcohol (alky). It is hardly the best example around. These cars are all high performance cars and efficiency is the last thing in the world most of them consider. Since efficiency is very nearly our number one ticket item, any comparisons with these vehicles are futile. A better comparison in some respects, is the fact that alcohol makes an excellent rocket fuel. Rocket designers have fuel efficiency as their number one design target. But since most of our vehicles do not use rocket engines, even this comparison falls short of its target. In the long run, ethanol will have to prove itself versus the next best fuel in both performance and availability.

The comparison between ethanol and gasoline will get better through the years as especially designed motors and vehicles come off

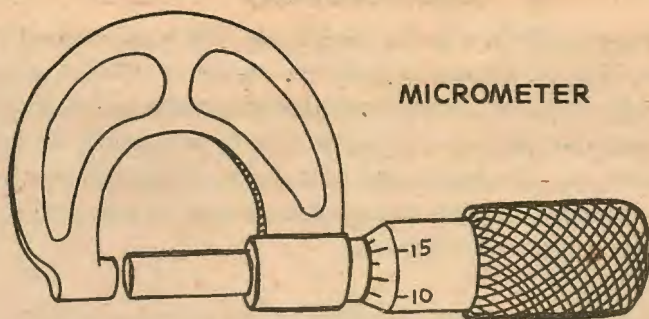
* As little as one part CO per 500 parts of air will result in death in about 3 hours.

the assembly lines. After all we are now expecting ethanol to outperform gasoline on gasoline's home turf! The home team always does better. Gasoline is burned in an engine that has been designed for gasoline and perfected over a period of almost 100 years. It will be a whole new ball game when ethanol is burned in an engine that has been designed and perfected with ethanol in mind.

Until that happy day, what are we to do with our present inventory of millions of gasoline motors? A good deal of experimentation needs to be done. Fortunately, all of the present framework of the engine such as fuel pump, radiator, valves, etc. will work with ethanol as-is without any alterations in their basic structure. The main point of difficulty is the carburetor. Carburetors in older cars before pollution controls and four barrels were relatively simple. There was generally a running jet and an idling jet and little else of any complication. In a pure ethanol system, many of these pollution devices can be discarded*. Some cannot. For instance, the afterburner for the crankcase will still be needed.

Resizing the carburetor jets is the most important single item to consider. Since each motor has its own carburetor design and since many of them differ widely in appearance and application we cannot begin to discuss all the problems associated with re-engineering these devices. We would need a book many times the size of this entire volume. But some helpful hints can be given. Fortunately the jets need to be larger and not smaller. You can purchase a carburetor book or manual (carburetor repair kits are economical and usually contain a complete blow-up diagram of your carburetor - this could be a wise investment for an experimenter) for the model you have and locate the running jets. Work on them first. They will need to be drilled out (if this is possible on your carburetor) about an extra 30 to 50 percent. Experimentation is needed so start with a small value.

* But never, never forget about the federal government. There is a fearful penalty (a cowed citizen is a happy citizen) for altering or removing any of the Rube Goldberg mess under your hood. Draco is alive and well. He writes some of our federal laws for us.



Find out what size the jets presently are and where they are located. There may be more than one if it is a multi-barreled carburetor. Your carburetor book or specs sheet may give this information. If it does not then find the jet and pass a series of number drills through the hole until you find the one nearest in size. Then either use a micrometer to determine the drill diameter or look it up if you know its number. You will need a set of number drills (1 to 80) and small fractional drills if you are to touch all bases. If you find the jet size is, say, .0520, this will be a number 55 drill. To enlarge it 30 percent means we want to enlarge the area of the tiny jet hole by 30 percent and not the diameter of the drill you will use. It is not the same thing, believe it or not. Since we desire the hole to be 30 percent larger, this is another way of saying we want it to be 1.30 times as large. To increase the size of anything by a certain percentage, we convert the percentage to a decimal and add one. Thirty percent becomes .30 and $.30 + 1$ is 1.30 or 1.3. Thus a 35 percent increase will be a factor of 1.35, etc. To find the value of the new drill, we multiply the old drill size by the square root of 1.3 ($\sqrt{1.3}$). You may or may not understand why. It doesn't make any difference. Just do it. You don't even need to know what a square root is. Any cheap calculator will do it in a jiffy for you. And it doesn't know what it is either! Thus, using our example of an original jet size of .0520, we get:

$$\text{for 30 percent increase} \quad .0520 \times \sqrt{1.3} = .0593$$

$$\text{for 35 percent increase} \quad .0520 \times \sqrt{1.35} = .0604$$

etc.

etc.

.0593 is approximately a number 53 drill and .0604 is approximately a number 53 or 54. Remember these are experimental holes so you needn't fret if you can't find the exact size drill you think you need. Use the closest one. Work in this manner little by little trying out each respective size. This means after each prospective enlargement you must reassemble the whole carburetor and try out the engine. The life of a novice genius is not an easy one.

If the hole is still too small the engine will not run smoothly and may missfire a bit. Remember, it won't run smoothly at slow speeds until you alter the idling jet also. So you have to try the engine out at low, medium and high road speeds. If it runs fine, it means the jet size is either right or a trifle large. If too large, it will waste fuel. This is why you creep up on it by drilling slightly larger holes in small increments and try it out each time. When the main jet is finally about right, then you can repeat the whole thing on the idling jets to get a satisfactory low-end performance. Remember that everything we are describing here may be so much useless information for your own carburetor. But the procedure of attack will be the same.

Ethanol burns a good deal cooler than gasoline. Your thermostat will regulate the temperature of the water but you may find it more economical to put in a smaller radiator. The motor will take longer to heat up on Ethanol and consequently will run rough longer. Preheating of carburetor air (through the manifold or radiator heat) is recommended when using Ethanol although some system will need to be devised so you do not overdo it. As mentioned before you will need electric heat if you are going to heat the carburetor air before you start the engine. There is no radiator or manifold heat to draw from in a dead cold engine.

It should be apparent by this time why it is not advisable to produce largely varying degrees of purity of Ethanol if one is considering using the product as a large scale fuel. Different carburetor adjustments would be needed over widely varying percentages of purity. If your fuel is 30 percent water, the orifice in the carburetor jet will need to be larger for a given power output of the motor than if there was only 5

percent water. Some tolerance is quite allowable. Notice that no adjustments are necessary when using the 10 percent gasohol mixture. By the same token, no adjustments would be necessary if the purity of the ethanol ranged from 95 percent to 90 percent, for example. But large excursions would require carburetor adjustments. Some methods have been devised to allow a continuous adjustment of the orifice over a limited range from the outside of the carburetor. A number of experimenters have also devised their carburetors with easily changeable jets so they can switch back and forth from gasoline to ethanol. Another method utilizes a small tank of gasoline (perhaps one or two gallons) in conjunction with the large ethanol tank. This is an advantage for starting purposes. The motor is switched over to gasoline to start it and then switched back to ethanol once it is running. The number of the variations is endless but this should give the novice experimenter some food for thought – or should we say fuel for thinking?

LEGALITIES

As we have written before, it is illegal for individuals to distill ethanol in any quantities – even a drop! You can legally ferment 100 gallons per year per adult for beverage purposes. You do not need a permit and you pay no tax on it. But 200 gallons (100 gallons each for man and wife) of fermented wine or beer will not produce enough wash to distill for very long. Not much pure ethanol will result from the distillation.

Since any serious experimenter will eventually need to ferment hundreds (and perhaps thousands) of gallons and will need to try out several, if not many, many still designs, it is obvious that either the law will have to be broken or some accomodation by the authorities must be made. Authorities, by their very nature, do not make many accomodations to suit the needs of individual citizens. But for large groups of citizens accomodations are easily arranged! After the petroleum situation became quite critical and a matter of national peril (and not until!) the government commenced issuing variances to the law for experimenters. A variance is a legal maneuver to actually

set aside the law for certain officially approved activities that are large enough to warrant attention but not large enough to justify rewriting the statutes. The variances currently being issued are good for experimentation and expire in two years.

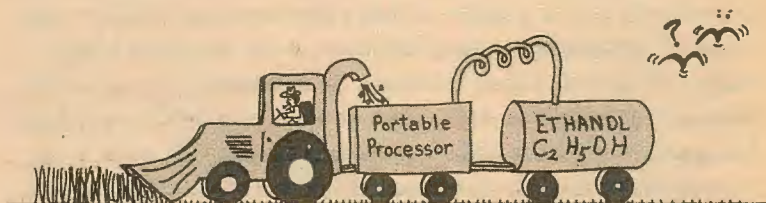
Unfortunately the variance for alcohol distillation will require that you give a lot of nonsense answers to a lot of nonsense questions. But this is to be expected and there is no need to get in a ferment about it. Don't blame the bureaucrats. They have to answer to Congress. To obtain a variance you need to write to your Regional Director of the Bureau of Alcohol, Tobacco and Firearms (BATF or sometimes simply ATF). Their names and addresses are listed in Chapter 12. A sample letter is listed in Chapter 12 also. You can copy this letter or write a similar one of your own. But the points mentioned in the letter should be included in your own letter. If the BATF needs further information they will write and let you know. They will not be fast but they won't be all that slow either. Expect your answer within 30 days unless they are backlogged. We have always found them to be courteous and helpful.



According to my calculations, if we simply burn it there's enough energy there to last at least til the next ice age is over!

CHAPTER 10

Medium Scale Production of Ethanol



FERMENTATION FOR ETHANOL FUEL PRODUCTION

Fermentation was discussed in Chapter 4 in regards to beverage production. We will re-discuss some of these items in view of the fact that we are no longer concerned about food-grade quality and are now interested in rather large scales of production. Even though we are no longer concerned with food grade quality, this does not mean we can throw cleanliness and good practices out the window. Yeast have their natural enemies also. If such things as normally clean containers, proper pH values, proper nutrients, etc. are not provided, we stand a good chance of ruining a batch of mash. Since we are talking about relatively large batches, we cannot afford to let this happen. But we no longer need to worry unduly about whether some of our mash or wash comes into close contact with a little aluminum or lead. We need have no concern whether the containers we are using are those we would not eat from (a large clean wooden trough or cleaned steel oil drum for instance).

The larger scale of production does pose many different problems. We will be discussing running a distillation column in a continuous manner in a later section. This is so that it can be kept running at optimum efficiency. It is not so easy to keep a fermentation running on a continuous basis. A mash is either fermented out or not. But the

mash can be fermented out most of the way and then transferred to another "finishing" kettle while the next batch is brought in and started. This is not always desirable but is sometimes used.

In previous chapters we recommended as much as a week or two to ferment the mash out completely. Now we are interested in speed and efficiency of the fermentation. Consequently we will expect the fermentation to be over and done with in a few days time. With the right nutrients, temperature, yeasts and mash, it can be done in a day. Of course we are no longer interested in necessarily having a high alcoholic content in the wash. What we want is to have a very high fermentation efficiency (little or no starch and sugar left in the wash). We don't care if it is only 10 or 12 percent alcohol or thereabouts so long as all the starch and sugar have been fermented out. We are going to be running it through a still anyhow. So we can use a more dilute mash if it suits our purposes and speeds things up. Of course we don't want to carry this to such an extreme that it requires a lot more heat in the still (boiling off all that excess water) or we trade off a good thing for a bad thing and come out even-up. We want to come out ahead.

The pH of the mash should be about 5.4^{*}. In any event, the pH should be above 4 and usually between 5.25 and 5.5. The starches and complex sugars should be broken down to simple sugars before introducing the yeast, of course.

Bulk mash will many times be produced directly from farm products. Table I gives a list of a few common farm products with a breakdown of their energy constituents. We are interested in those that can easily or fairly easily be broken down into simple sugars. There are many, many excellent fruits, grains & vegetables that are

^{*} pH is a measure of the acidity. For a full discussion of pH refer to the book MAKING WINE, BEER & MERRY (see last page in this book). If you do not have access to a way of measuring pH you can write to the Home Wine and Beer Trade Association whose address is in the appendix. They can send you the name and address of the closest Home Wine Retail store or mail order outlet. Or write to one of the other sources in the appendix. From these you can obtain yeast, yeast nutrients, measuring instruments, mash recipes and almost anything else you might need for fermenting.

TABLE I
Approximate Percent Major Constituents
in selected farm products

PRODUCT	WATER	PROTEIN	FAT	SUGAR STARCH	CELLULOSE	ACID CONTENT
Potatoes	80	2.1	.1	17.2	.5	.5
Soybeans	10	34	18	29	5	--
Barley	12	9	1.4	75	1	.1
Corn Flour	12	8	3	75	1	--
Rye	11	10	1	77	.5	--
Wheat	12	13	2	69	2	--
Rice	12	7.5	2	77	1	--

NOTE: These will not total 100 percent since small things such as vitamins, minerals, etc. are ignored.

not listed. Avoid anything with a high content of protein, fats & cellulose. We desire those with a high content of SUGARS & STARCHES. Potatoes, Barley, Corn, Rye, Wheat and Rice all satisfy these requirements to a greater or lesser extent. Soybean was included in the list to give a representative member that does not qualify. It has too much protein which is a little more difficult to efficiently convert to sugar. Potatoes have a lot of water, which is a minor disadvantage, but much of the remainder is starch. Table I lists only a few of the many good candidates for mashing & fermentation.

To ferment out these materials, enzymes must be added to break down the starches. These enzymes can be purchased from companies such as Independent Laboratories or Home Wine Retail stores (in some cases). Addresses for these are in the appendix. In a great many cases, you can make the proper enzymes yourself by malting one of the grains. Barley is the commonest, but corn and other grains can be used. The malting and mashing process is given on pages 46-51. For

grains such as corn, the optimum mashing time and temperature is 45 to 60 minutes at 145 degrees F. About 5.5 gallons of Ethanol can theoretically be produced from a bushel of corn. But this is like EPA gas mileage – don't expect it! After the fermentation is over, the residue makes an excellent high protein cattle feed. The breweries & distillers sell their excess spent grains as cattle feed and it is commonly called DDGS (Distillers Dried Grain & Solubles). It is a valuable and rich cattle feed. DDGS is usually fed as a supplement to regular feeding rather than as a food all by itself.

You can malt all of your grain to be converted or you can malt only 10 to 25 percent and add this to the unmalted grain during the mashing process. The latter method gives a higher yield of ethanol. If you make your own malt, set it aside and boil the starchy mash (corn, wheat, etc.) vigorously to break down and separate the starch from the fibers. Then let it cool to about 145 degrees F. before adding the prepared malt and going through the hour or so of mashing. Check it with an iodine solution as outlined on pages 50-51 during mashing to determine when it is properly converted to sugar. Then let it cool to room temperature (below 85 degrees F) before pitching* the yeast. Add any nutrients deemed necessary (such as B vitamins which are very good) and keep the mixture warm but below about 90 degrees F. The activity level of the froth should give you a good idea when it is finished. Also you can draw off some of the liquid on top and check it with a hydrometer*. This will not give you an exact indication of when it is done, but when the hydrometer reading drops to 0 specific gravity, or perhaps a little below, you can assume your mash is all fermented out and ready to distill.

GROWING YOUR YEAST

Good quality brewing yeasts can be purchased from any Home Wine Retail Outlet or mail order store. Failing this, you can use bakers yeast with satisfactory results. A good brewing yeast should brew

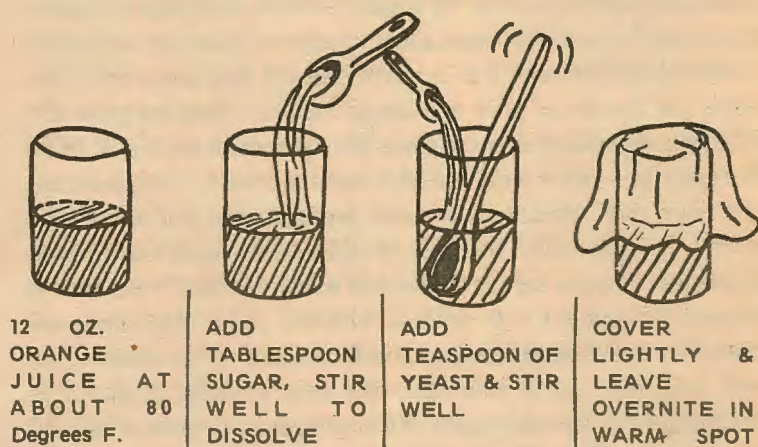
* Brewers term for adding yeast

* *Can be purchased at Home Wine Retail or Mail Order suppliers.

quicker and cleaner however, making it easier to distill. Brewers yeast usually comes in 5 gram packets. 5 grams is about a teaspoonful. However, yeast is much like corn or wheat. One handful of corn is enough to seed the entire state of Iowa or every state in the United States if you are willing to wait enough generations to build the crop up. Fortunately yeast generations only take minutes and hours rather

FIGURE 1

Preparing a Starter Yeast Batch



AFTER VIGOROUS FROTHING HAS COMMENCED ADD 12 MORE OZ.'s OF YOUR MALTED MASH & ONE TEASPOON OF SUGAR, STIR WELL AGAIN.



AFTER VIGOROUS FROTHING HAS SET IN (about 12 hours) THE YEAST IS READY TO PITCH

than years and years. Although one packet of yeast is enough to grow your own from, it is foolish not to keep a good ample fresh supply on hand. You do not want to stretch out one packet too far or contamination can creep in.

Here is how you grow your yeast before putting it in the mash. Take a 12 oz. glass of orange juice made from frozen concentrate (make it extra strong) and add a tablespoonful (three teaspoons) of common sugar. Stir it well to dissolve the sugar, heat it to about 80 to 85 degrees F. and add the packet of yeast (about 1 teaspoon). Stir very well again. Cover lightly and leave it in a warm (but not hot) place overnight. Better put the orange juice in a larger container than the glass or it will froth and spill all over the place. Maybe a small saucepan. In the morning there will be froth and other signs of activity. Your yeast has multiplied many thousands of times overnight and you now have a healthy growing colony. Now take 12 ounces of the mash that is ready to ferment, making sure it is nice and warm, but NOT over 85 to 90 degrees F., and put it in the pan with the yeast. Add about one teaspoon more of sugar (teaspoon, not tablespoon) to this mixture, stir well, and leave again overnight. The next morning it should be working away vigorously again. If it is not then your mash is bad and do not use it. There is very little likelihood of this if you did your mashing and malting correctly. If it is working vigorously then it is all ready to pitch into the mash. You will have about 24 ounces of good, active yeast solution. If you are intending to keep this yeast generation going, then remove about 4 ounces of it and put it in another 12 ounce glass and start the process all over again. But don't do this too many times before you start fresh again. The yeast colonies may change with succeeding generations (just as we all do) and you may eventually end up with a colony that is either contaminated or does not convert sugar to ethanol efficiently. You will now have 20 to 24 ounces of yeast solution. This is easily ample to start a barrel (50 gallons or so) of mash. If your batch is larger than this, then start out with a little larger proportions of everything (except the yeast) in your starter batch. A good rule of thumb is to use at least a quart of starter batch for each 100 gallons of mash.

Pitch the yeast colony (called a yeast starter batch) and then mix the mash vigorously with a wooden paddle or whatever. It would not be over a few hours time before you notice the activity. With healthy yeast and a well-prepared starter in a good mash, the ferment can be over in as little as 8 to 10 hours. More likely, though, it will be at least two days and maybe three or four. For a thorough coverage of the basic theory of fermenting and fermentable products, refer to the book **MAKING WINE, BEER & MERRY**.

For every pound of sugar in your mash, you will theoretically get about $\frac{1}{2}$ pound each of Ethanol and Carbon Dioxide (CO_2). In small operations, the CO_2 is simply bubbled off into the air. However if you have a large batch going, a lot of carbon dioxide will be given off. You may want to devise a means to capture this and solidify it into dry ice. But do this only if you can locate a ready and profitable market for it. Packers and shippers are several good candidates.

EXPERIMENTING PRODUCES EXPERTISE

Do not start off the first batch you make on a large scale. Start off with a gallon or two and gain some experience. Experiment until you feel quite competent with your methods and materials. Then, and only then, gradually increase the size of your batches until you are up to working scale. Unless you have ample money to throw down the drain which is where bad batches go!!..

PREPARATION FOR DISTILLING

When the mash is through fermenting it is ready to be used as a wash in your still. Let it settle out as much as possible and then syphon or otherwise remove the liquid from the spent grains as far as possible. Then let set another day or so to settle more and once again syphon, ladle or otherwise pour off the top liquid. It would be very good at this time to devise a coarse filter that was easy to reclean. Much time could be saved. Instead of wasting a few days waiting for the lees or residue to settle, you could merely send the mash through your

filter and put it in the still directly afterwards. A very fine metal screen should do. If it is too fine it will clog immediately and forever need cleaning. If it is too coarse, it will leave so much residue that your still will soon get plugged up. A superior solution would be to have several grades of screens that were either used one after the other or in some simultaneous combination. There are a number of companies that manufacture ready-to-use filters of various sizes and grades.

In any event, once the bulk of the solids have been removed, the wash is ready to put into the still and should be done so immediately. It is best not to let any fermented washes sit around for any length of time. Unless they are very high in alcohol content, they tend to succumb to such things as vinegar bacteria and slowly turn to vinegar. There are also spores, algae, etc. which find your wash a perfect home. Once you have distilled out the ethanol it is a natural preservative itself. Practically nothing will disturb it in the 90 to 95 percent state — except evaporation. Keep it tightly sealed.

DISTILLATION OF ETHANOL FOR FUEL PRODUCTION

In Chapters 4 and 5 we discussed fermenting and distilling in some detail. It seems reasonable to suppose that the same theory would apply when making ethanol for fuel. It does. But, because the final product is to be used for fuel and not as a beverage there are some economies that can be effected. Further, the scale of production will necessarily be larger. Your car can consume more ethanol in a day than you could drink in a year! If you are going to satisfy its thirst you will need to build much larger stills. Although the basic theory is the same for any size still, the practical aspects are not necessarily the same.

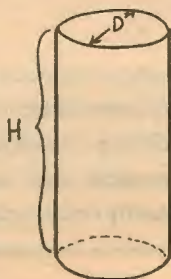
Of course such things as pressure cookers on the stove and using marbles in the reflux column are out. You can now use any reasonable type of material for your still and for the condensing coils. Even a car radiator can be used for condensing. For experimental models almost any type of metal can be used. Then when a good working prototype

evolves, it is wise to replace with stainless steel or equivalent most of the parts of the prototype that actually come into contact with the ethanol vapors. This makes good sense from an economical point of view. In spite of its name, stainless steel will corrode, but the corrosion is small and so slow the extra investment needed to pay for it is well spent. It will last and last and requires little if any maintenance. This is important too.

CONTINUOUS DISTILLATION

For large scale production, it is much desired to have your still running continuously rather than in intermittent batches. The pressure cooker method is a good example of a batch process. The system has to be stopped, cleaned, loaded and, worse yet, reheated. The fractionation column illustrated on page 69 is a good example of a continuous run still. This will be the model used as an example for ethanol production on a large scale. All of the essential details are there. A large, solid metal cylindrical shell capable of withstanding moderate pressures is needed, first and foremost. This will form the column itself. It can be anywhere from six inches in diameter up to several feet in diameter. The length (height) of the column should be anywhere from 20 to 40 times the diameter. Figure 2 gives the method of computing the volume of a tank in gallons. If it is a cylindrical tank you need know only the diameter and length (or height depending on your viewpoint).

Figure 2
Capacity of a cylindrical tank



D is diameter

H is height

The volume is approx:

$$V = 5.88 D^2 H \text{ gallons}$$

where H and D are in

feet and D^2 means $D \times D$

BUILDING A FRACTIONATING COLUMN

A rough rule of thumb for the column size (for medium size columns) is 8 to 10 gallons of column capacity for each one gallon of ethanol you wish to produce per hour. For instance if you chose a one foot diameter tank that was 25 feet long, you might be able to realize about 18 gallons per hour from it if everything was properly designed and balanced. (Tank capacity = $V = 5.88D^2 H = 5.88 \times 1 \times 25 = 147$ gallons. $147 / 8 = 18.375$ or about 18 gallons per hour of 90 - 95 percent ethanol). That is a large IF. For your design you may find that there is an optimum length to diameter ratio.

A 40 foot tank, 3 feet in diameter would give a projected flow rate of:

$$V = 5.88 \times 3^2 \times 40 = 5.88 \times 9 \times 40 = 2117 \text{ gallons}$$

$$2117 / 8 = 265 \text{ gallons per hour of Ethanol}$$

Of course this means a gosh-awful amount of wash* would be fed into this creature to keep it running continuously.

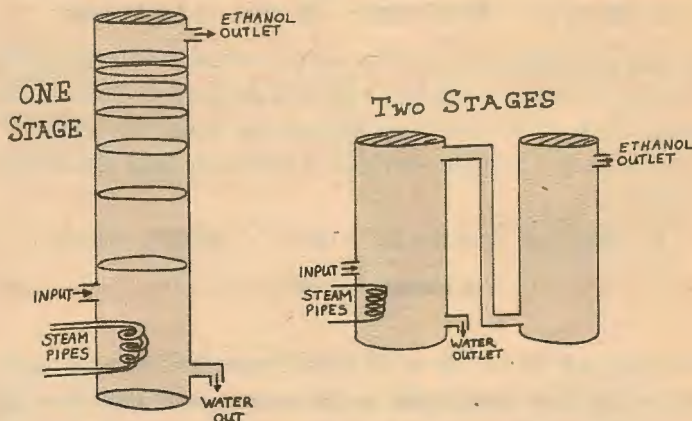
It is clear that the large size of the column needed can create some difficult technical problems. If it is built outdoors or indoors it will have to be well insulated or it will be so inefficient as to be worthless. Whether it is inside or out it is going to weigh a bit. A concrete pad will need to be built under it to withstand this weight. A heat delivery system will need to be supplied. Steam pipes into the bottom of the tank are a popular and efficient method of introducing easily controllable heat with a minimum loss. In the next chapter we will discuss some ways of furnishing heat to make this steam.

One popular method of avoiding the huge size of a single structure is to break the tank down into several smaller tanks and then connect the top of each tank to the bottom of the next one. Naturally the connecting link needs to be well insulated so there is no appreciable heat loss during this transfer. The internal baffle plates are usually constructed

* Also called mash or beer by various writers.

Figure 3
Separating the Distillation into Stages.

This keeps the hardware from being too bulky and clumsy to properly manage & maintain



closer and closer together as the top of the cylinder is approached. Figure 3 shows some examples of this.

BAFFLE PLATES

The construction of the baffle plates will require some care and work. Each plate should have at least three or four holes drilled in it. The holes should not be too large or the distilling action will be reduced. On the other hand if they are too small the still will clog and need cleaning oftener. No larger than $\frac{1}{2}$ inch and no smaller than $\frac{1}{4}$ inch is a good rule of thumb. Make sure that each plate has at least five percent of its area in holes. Here is a handy formula to determine how many holes you need for five percent holes in any diameter plate:

$$N = .05(D/d)^2$$

where D = Diameter of plate in inches

d = diameter of holes in inches

N = number of holes needed

For instance if you have a 12 inch diameter column (one foot) and you want to drill $\frac{3}{8}$ inch holes, then the number you will need for five percent holes is:

NOTE: $\frac{3}{8} = .375$

$$N = .05(D/d)^2 = .05(12/.375)^2 = .05(1024) = 51.2 \text{ or } 51 \text{ holes}$$

This simple formula can be used for any percentage of holes simply by changing the percent you want to a decimal and use it as the multiplier in place of the .05 we have in our formula (for 5 percent). Thus for 9 percent holes of $\frac{1}{2}$ inch diameter in an 18 inch baffle plate, the formula would be:

$$N = .09(D/d)^2 = .09(18/.5)^2 = .09(36)^2 = .09(1296) = 116.64$$

or about 117 holes.

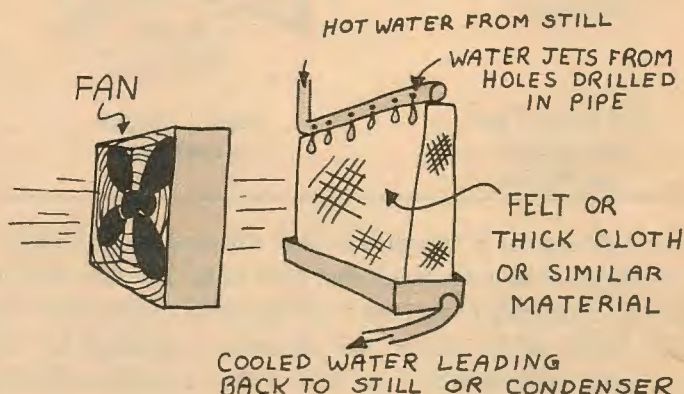
Notice on page 69 that the small upward pipes for the vapor have a little metal roof on them similar to the common cover used over vent pipes on the roof of your house. Only these, of course, are smaller in size. These "roofs" help trap and condense the water vapors. Notice also that there is a small standpipe leading downward and irregularly placed to bleed off the condensed water to the next lower level. As the Ethanol vaporizes upward we wish the water to condense downward. The water is removed at an appropriate point under the input wash feed point. In some designs a small amount of the final alcohol is fed back down through the system again at or near the midpoint. Apparently this has a regenerative effect such as feedback in an electronic circuit.

BUILDING A CONDENSER

As mentioned before, a car radiator (or several radiators) can be used for cooling. The water /ethanol mixture has a slight amount of corrosive action on lead and aluminum. One or the other or both of these metals will usually be found in most radiators. The corrosive action is very small so very little lead will likely get into your ethanol. Another solution for cooling a large production output is to immerse some very long copper tubing (or other malleable metal) wound in a

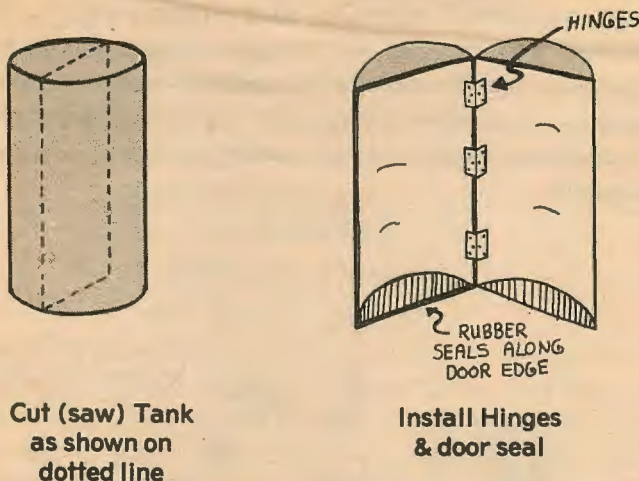
compact form into a bath of freely flowing cool water. The water is pumped over a small evaporative cooler which uses felt or similar pads to cool the water. The water is cooled by its own evaporation. Then the cool water is returned to the condenser on the still for re-use. See figure 4. Evaporative coolers are very common in the southwest U.S. and ample literature on their construction can be found in any good library.

FIGURE 4
Evaporative cooler



CONSTRUCTION PROBLEMS

Another problem arises in the construction of the tank or tanks to be used for the column. How can you get all of those metal plates in there and build all of the many, many small standpipes, covers, return tubes for the water, etc.? This is where ingenuity comes into play. Everybody has their own solution and there are many clever ones floating around. A suggested method is shown in figure 5. Simply cut the tank right down the middle with a hacksaw (single ended so you can get inside the tank with it) or let your local machine shop do it. You can't use a welding torch as it will leave such a rough edge you will probably never be able to get it to seal back together again — which must be done. File the edges smooth, install hinges, and find a good rubber gasket to fit along the edge to form a seal when the door is closed. The seal material must be able to withstand temperatures up

Figure 5

to at least 250 degrees F. Of course the door will need a solid clasp, or several clasps, to hold it securely shut when using. The seals need to be good but remember do not have to withstand heavy pressures. The pressure inside will be greater than atmospheric pressure, but not much greater. Once this is done you can now construct baffles inside to your heart's content. They can be welded into the inside of the back part of the tank and rubber seals put on the outside half so they will seal against the door when it closes. Remember that seals *inside* the tank need not be perfect. A good close fit is needed that is mostly water tight, but might leak a trifle.

BUILDING A PROTOTYPE

By the way, before you go to all of the work of constructing a large tank in final detail (or a large *anything*) put together a smaller prototype built to scale and experiment with it to get a good design. Then build a full size prototype - making all the proper modifications - but don't take the pains with it you will on the final model. Make it good but not great. After you have this scale model debugged and

working satisfactorily, you are ready to start building the final working model and incorporating all of the improvements you have discovered from your first two prototypes. It is a lot of work but it is very hard to describe that delicious ecstatic feeling that follows the first successful run of the final model (the first successful run may actually be the 52nd trial run after debugging). In Chapter 12 we have listed quite a few sources that can be of help to you.

OPERATING THE STILL

Along the length of your column you should have at least three or four thermometers and-or pressure gauges. Since the volume inside the tank is constant the pressure is proportional to the temperature. What this means is that you should only need a battery of thermometers to give you a good idea of what is going on. Thermometers are cheaper than pressure gauges. The readings on the thermometers should start at somewhat above the boiling point of water at the lowest point on the tank and decrease to the boiling point of ethanol (about 173 degrees F. but may be different in your area) at the other end of the column (top end). If four or five thermometers are carefully placed along the length of the column they should gradually read lower and lower values up the column. For instance when the column is operating at a steady rate, the lowest thermometer (below the level of the wash input) might read 215 degrees or even 220 degrees F. Never let it go higher than that. The thermometer at the input level for the wash should read about the boiling point of water (212 degrees F at sea level) and each thermometer upward from this point should read lower on the scale. At a temperature of 220 degrees F. the pressure above atmospheric is only about 3 pounds so a considerable safety factor remains. If one thermometer should start reading higher than either of those around it (a hot spot) it means you have a plugged plate at that point. If you avoid putting solids through your still this is unlikely but it can occur. You will need to shut down the operation and clean it out. This is a good argument for keeping all solids out of the still. Only liquid wash should be allowed to go through it. Even then you can get a lot of foam from proteins and other undesirables.

For an extra safety factor, you can weld a standard pipe fitting into the top of the tank (or each tank) and install an economical pressure release valve sold for hot water tanks. Buy one with an adjustable setting and set it as low as it will go.

ADJUSTING THE TEMPERATURE & FLOW RATE

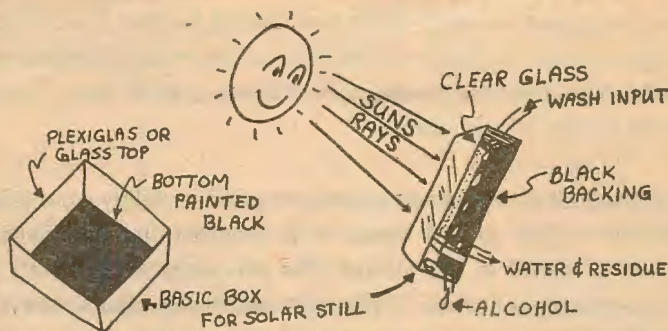
You can vary the temperature up and down the still for optimum operation by several methods. One way is the obvious one of increasing and decreasing the heat supply. Another equally good one is to regulate the flow of the wash into the still. Increasing the flow of wash will drop the internal temperatures and decreasing the flow will cause the internal temperature to rise. For a continuously operating still you will eventually have to determine the rate of continuous flow of wash into the still that keeps the temperature gradient in the ranges we have discussed.

The water residue from the bottom of the column is distilled also, recall, and therefore can be used where distilled water is required. This includes wet-acid batteries and steam irons. However a bad feature is that if the water is very hard in your area the inside of the column will tend to become clogged with scale and deposits from the minerals in the water. The design of the still should allow for this eventuality and provide methods to minimize such deposits and-or clean them out if it does occur. One way of minimizing these would be to use the residue water from the first wash through as part of the water used to ferment out following batches. By so doing you would not re-introduce a large fresh supply of minerals with each new batch from the fermenter.

ENERGY INPUT & ENERGY LOSSES

In the first rush of excitement over GASOHOL, many experimenters tried using solar energy as a distillation heat source. It will work. One method is to use a large rectangular box placed at an angle to the sun. Figure 6 shows the construction. The box is sealed. The top is covered

FIGURE 6
Solar Still Design



with clear plexiglass facing into the sun. The bottom is painted black to absorb the heat (heat is one form of energy) from the sun's rays. (White reflects heat, black absorbs it). The box is at an angle constantly facing the sun. As the wash slowly comes in the top, the alcohol evaporates from it first and then condenses on the cooler plexiglass or glass surface. It runs down this surface into the small catch basin at the bottom and is removed at this point. It is simple enough. Obviously it is inefficient (a lot of water evaporates, too) and show and depends on the sun which is not dependable in some places. But it does work. And it is a good first prototype to work on. This design is by Lance Crombie who has devoted a lot of time and attention to solar stills and ethanol fermentation and distillation. He is one of the pioneers in this modern field .

Other heat sources include methane (see next chapter), wood, coal, your own ethanol or refuse oil from crankcase drainings. No matter what heat source is used it is important to use as little as possible. In a large scale operation even a small heat loss can add up to terrific inefficiencies over a short period of time. As much time and attention should be given to heating and heat loss as to any other of the major areas of design.

* He has written a book on his experiences, **MAKING ALCOHOL FUEL**, published by Rutan Publishing, address in back of book.

DENATURANTS & TAXES

If Ethanol eventually does become a universal fuel being used on the scale gasoline now is, a large battle looms on the horizon. It is difficult to foresee whether the battle will be with bureaucracies, legislatures, private groups, religious groups, none of these, or all of these. This is over the matter of adulterants.

At present all non-beverage alcohol produced is rigidly controlled. Except for a few special cases, it is required that adulterants (poisons) be added to this alcohol. The philosophy behind such an extreme measure is obvious. If you drink adulterated ethanol to avoid paying the tax, the penalty is death or blindness. In few other areas do we allow such absolute madness to prevail. But since we all grew up with this system it has a way of seeming to be the natural order of things.

Unfortunately, many of the very institutions in our society that should be appalled and oppose this intentional adulteration (religious groups, civil rights groups, etc.) have their own moral or other axes to grind and acquiesce in this kafkaesque (gruesome and weird) behaviour.

Continuing this adulterating scheme on a product so widely distributed and used as a basic fuel will result in increasingly large numbers of dead and blind amongst the young, the ignorant and the unwary. As bad as this seems it is not the worst of the picture. The total number of such mishaps probably would not even approach the number of motorists that are annihilated each year. We have learned that we can live with these numbers quite comfortably. The real problem is the bureaucracy that will come into existence. The involvement by the government in more details of our lives will be enormously expanded. New harassment laws with no social benefit (carrying unadulterated fuel, using unadulterated fuel, selling unadulterated fuel, etc.) would be passed. New forms will be devised requiring producers and distributors to hire people to fill them all out

and mail them in quadruplicate to Washington, D.C. (or your state capital). The user will pay the bill for this in increased prices, lower availability and lost time. It will simply build a large overall national inefficiency factor into the entire fuel situation.

On the other hand, a tax on Ethanol as a fuel is inevitable. Assessing reasonable taxes to pay for reasonable services is one of the prime functions of government. Without taxes we wouldn't have highways, airports, sewers, running water, and that great feeling of relief on April 16 each year. But we do not need to continue practices that have long outlived their usefulness or need -- indeed if there was ever any real need for the adulteration of ethanol.

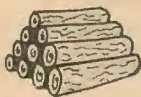
Most people are not going to drink ethanol fuel because of the obviously unsanitary (from a human standpoint) handling it receives from production through distribution. The taxes lost through beverage taxes will be tiny compared to the huge yield that will result from ethanol fuel taxation.

CHAPTER 11

More Replenishable Fuels & Topics



ETHANOL
(liquid fuel)



CELLULOSE
(solid fuel)



METHANOL
(liquid fuel)



METHANE
(gaseous fuel)



Some replenishable fuels, showing one of the commonest & easiest methods of production

SUNLIGHT

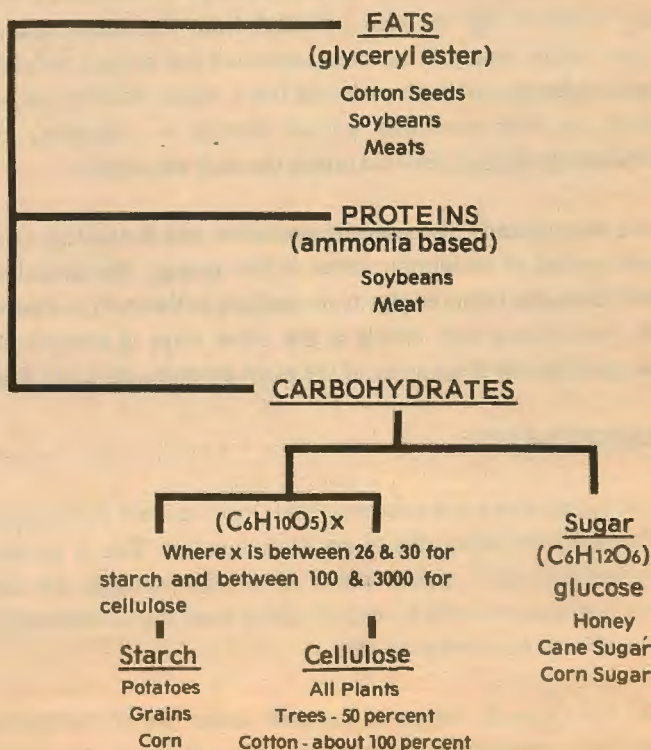
There are other good replenishable fuels besides those few we have discussed so far. Replenishable fuels derive their energy from the same source we do: the sun. Except for nuclear energy, the sun is the source of all the energy for all the food we consume and all the fuels we burn, including gasoline and coal. The problem with gasoline and coal is not that they are not replenishable, because strictly speaking they are, but replenishment takes thousands of years and enormous natural resources for a very low yield. If we can sometime in the future find a way to speed up the process we may return to the use of gasoline. Don't look for it to happen soon.

Since the sun is the source of all our energy (except nuclear), it would be most efficient if we could convert sunlight directly into whatever work we wished to do. Light a bulb. Turn a motor. Heat a room. This is the direction that a good deal of research is now taking. Solar panels are one result of this research. At the present time we have not been able to come up with any direct method that is economical or efficient enough for general usage.

However many good indirect ways of utilizing sunlight have resulted. Generators at the bottom of waterfalls are a good example of reclaiming the energy of evaporating water. Wind generators capture the energy caused by uneven heating of the earth's surface. Tidal generators that rise and fall with the tides capture the gravitational energy of the sun and the moon (the only exception to our first sentence in this paragraph is that we can harness a small amount of tidal energy from the moon's orbit around the earth).

FIGURE 1

Principal Constituents of Foods & Replenishable Fuels



STORED ENERGY CONVERSIONS

Better yet, we do have at our disposal a great deal of stored energy from the sun. All the food we eat comes from stored energy. Plants are able to use green chlorophyll to combine carbon dioxide (CO_2), water (H_2O), and air (Oxygen, O_2 and Nitrogen N_2) to store the energy of sunlight. Sunlight, falling on the green leaves, provides the energy to drive this food factory. Whole new groups of compounds are built up by the plants and stored in their tissues or fruits. Most of these new compounds are easily broken back down again with the resultant release of the stored energy of the sun. We use many of the compounds as foods. Figure 1 gives a breakdown of the principal constituents of foods. These same products form the basis for almost all of our replenishable fuels. The plants we grow and the foods we eat furnish us with an abundant supply of stored energy from the sun. We have only begun to tap the real potential from this huge natural and replenishable supply. It has been estimated that enough cellulose rots away on the ground each year (old trees, straw, dead weeds, etc.) to supply us with more than enough energy to completely replace petroleum products! And that is only the stuff we neglect.

We have already discussed fermentation and distillation as a very good method of reclaiming some of this energy. Fermentation and distillation give us the energy from sunlight in the form of ethanol. We will now discuss very briefly a few other ways of recapturing the energy of the sun from some of the plant products shown in Figure 1.

CARBOHYDRATES

Carbohydrates are a pandoras box. Once we start discussing them all hope of ever being able to say enough is lost. This is not because they are difficult to understand or so terribly complex. On the contrary it is because there is so much about them that is interesting and applicable to our everyday life.

We have already discussed to some extent two of the three most important carbohydrates. These are sugar and starch. Simple sugars

must be present if common yeasts (technically the commonest strain of yeast for fermenting is *Saccharomyces Cerevisiae*) are to produce alcohol. If starch is present it must be converted to a simple sugar before it can be fermented. Enzymes are a "natural" way of changing complex sugars to simple sugars or changing starch to simple sugars. There are also "chemical" ways of doing the same things. We have put natural and chemical in quote marks because there is hardly anything unnatural in this very natural world of ours. If it were unnatural it wouldn't be here. Enzyme action is still not well understood by chemists and is likely only a simple chemical (non-living) product of the plant or animal metabolism itself. If all this seems unclear, relax. There are plenty of smart people working on the matter even now while you are reading these words. Perhaps in a few days they will be able to tell us much more about the action of enzymes (and chemicals too!) than they can today. But we (society) know plenty enough to do the job we are undertaking in this section.

Although we have mentioned two of the common and important carbohydrates, we have said little or nothing about a very, very important third member*: cellulose.

CELLULOSE

Epimetheus opened the lid to Pandora's box and the only good thing that resulted was "hope". A jolly little bespectacled college professor, Dr. Christian Friedrich Schonbein, peered nearsightedly into his porcelain reaction vessel in Switzerland in 1846 and saw another hope of mankind. The puffy white substance looked like the cotton he started with. But it wasn't. For one thing, when ignited it exploded violently. He had produced nitrocellulose or CELLULOSE NITRATE.

Four huge and totally different industries arose from this humble beginning. The fine polished finish on your car (lacquer) is very likely a product of cellulose. The paper in this book you are reading is

* There are other carbohydrates besides sugar, starch and cellulose, but these three constitute the major ones of interest to us.

cellulose. Very likely some of the synthetic clothes you are wearing is cellulose. A good many of the plastics around you are produced from cellulose. Smokeless powder comes from cellulose. The sponges in your kitchen and the explosives used in the mines are both from cellulose. Is it any wonder that we dread starting on the subject of cellulose? How do you stop? In a standard sized book such as this one, we can only hope to touch the highlights.

METHANOL FROM CELLULOSE

The easiest way to re-capture sunlight energy in cellulose is to burn it. If you have a large supply of deadwood or trees, you can use this directly to heat your still. However, it is a little difficult to properly regulate the heat using wood. It is a little easier with coal, but still not easy. A way out of this is to produce methanol from the wood by heating it in an air-tight enclosure. When this is done a large amount of burnable vapors are released from the wood. These vapors do not burn in the hot atmosphere inside the closed container because no outside air (oxygen) is let in. The vapors are then let outside through a pipe and cooled by using a normal condenser just as with a still. The vapors contain many valuable products but the commonest is METHANOL or wood alcohol. It is a liquid at room temperature but readily evaporates (as does ethanol). Table II of Chapter 9 gives its prime characteristics. It can be burned to release heat the same as gasoline and ethanol. It does not have quite the energy of ethanol nor does it mix with gasoline as does ethanol. Methanol sinks to the bottom of the gasoline and stays there. Some chemicals can be added to the mixture to cause them to mix freely (be miscible) but this is generally not worth the time and attention considering some of the other disadvantages of methanol and the easy availability of ethanol. But methanol can be mixed with ethanol (don't confuse these two) as a fuel and used wherever ethanol and gasoline are used. Unfortunately it requires a large amount of cellulose to produce sensible amounts of methanol. As with ethanol, the residue of producing methanol is valuable itself. This is charcoal, and is used in steel production for a source of fairly pure carbon.

In our not too distant past, Methanol was produced entirely by heating certain hardwoods (such as birch and beech) in the absence of air. This is how it came to be called Wood Alcohol. However, now it is produced primarily by heating under pressure the two gases, hydrogen and carbon monoxide (both of which are relatively cheap) along with a catalyst such as zinc oxide or chromium oxide. In spite of its relative cheapness and availability, it is not nearly so replenishable a resource as is ethanol.

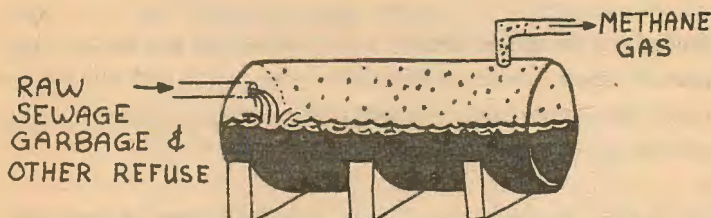
METHANOL is quite toxic. It is chemically altered by the body's chemistry as is Ethanol. However Ethanol is transformed to Acetyldehyde and acetic acid which can then be disposed of by the body so long as they do not accumulate too rapidly. Methanol, on the other hand, converts to Formalehyde and Formic Acid, both of which are very toxic. (Formaldehyde, when dissolved in water, is called Formalin and is used as an embalming fluid).

METHANE

Methane is another energy source, such as ethanol, which shows great promise for the future. It also is derived from another one of those processes that are simple in theory, like Ethanol, but fraught with complications in practice. We are going to discuss only the basics in detail. This will give you ample material to determine whether you are interested in experimenting with methane production and to get you started in the right directions. There are a number of good books on the market which explore this single subject in detail and which the interested entrepreneur or experimenter should purchase for his personal library. One of these is **THE DOS AND DONT'S OF METHANE** published by RUTAN Press, whose address is in Chapter 12.

METHANE is an odorless and colorless gas. It is the prime constituent of both animal and vegetable gases. Any smell associated with these gases is a result of other impurities. Sulphur dioxide, which smells like rotten eggs, is often associated with methane in animal gases.

FIGURE 2
Methane "Digester"



GAS EXPLOSIONS

Figure 2 shows a simple methane generator. You need only dump some garbage or sewage in a closed tank, put an exit pipe on the top of it, wait a few days and then start burning the methane gas that comes out of the exit pipe. That is the theory. The practical result, however, is that you may very likely find parts of yourself in the next county after lighting the match to the exiting gas. Methane is not a liquid at normal temperatures. It is a gas. This author has only the usual respect for such things as a pail of burning gasoline, for instance. So long as nobody kicks it over, the fire can be put out readily because it burns only on the surface. If you leave it alone it will simply burn itself out, and while this may produce some spectacular flames it can be kept confined and reasonably safe by cool heads and competent handling. Not so with energy in the gaseous state. Make a mistake with methane or hydrogen gas and you will be repaid with an immediate explosion. With gasoline or ethanol, or any liquid fire, it is true that you only have a short while to react as the flames will spread with great rapidity. But this is slow motion compared to an exploding gas. There is no reaction time once the chain is set in motion. This author approaches such bad actors with very great caution. So should you.

Each gas has an optimum gas to air ratio that produces the best explosion. Best from the point of efficiency, not the hapless observer.

Table I shows some limits of flammability (explosions) for some common gases. Where the material is normally a liquid (such as ethanol) the data given is for the vapor of the material.

Methane is the prime constituent of the natural gas we use in our homes. It should be treated with the same care and attention as natural gas. Notice that hydrogen is the baddest of the bad for explosions. It will explode at almost any concentration level. The maximum explosive force of each gas will be near the upper limits of these figures. Below the lower limit the gas is so sparsely scattered that it cannot continue burning when ignited. It damps itself out. Above the upper limit the gas is so predominant that there is not enough oxygen available to continue the burning process. It again damps itself out. But within these rather wide limits, watch out.

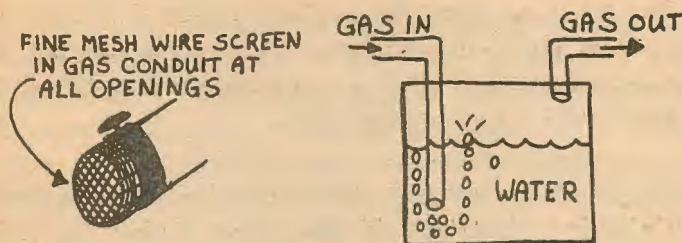
In a normal methane system there are a number of ways that explosions can be prevented. Sir Humphrey Davies (1778-1829) was the first to discover that if the gas is passed through a moderately fine wire screen it cannot carry the flame with it. The screen conducts away so much of the heat that it is cooled down below its flammable threshold and the flame goes out. He built a lantern on this principle (1816) which could be carried down into coal mines and yet not create any danger from the pockets of methane gas that exist in all deep coal

TABLE I

FUEL	EXPLOSION LIMITS
Methane	5 to 15 percent 5 to 15 percent methane to air ratio at room temperature & atmospheric pressure.
Ethanol	3 to 19 percent
Methanol	7 to 37 percent
Hydrogen	4 to 74 percent
Propane	2 to 9 percent

FIGURE 3

Some Explosion Safeguards



mines. The burning flame was surrounded by a fine metal wire screen, but other than this was out in the open. It is interesting to note that he took out no patent on this valuable contribution to mankind and the grateful coal industry in Great Britain presented him with a complete dinner service of silver plate as a token of its gratitude. So you don't have to pay Sir Humphrey a royalty if you use his idea! Figure 3 shows another explosion dampener. This is a water trap. The water trap does introduce water vapor into the gas however. There are other effective methods also. Using a very small diameter pipe at the final exit point can work much like Davie's lamp in that the small amount of internal gas to the large amount of surrounding pipe (proportionally) will serve to sap so much heat out of the burning wavefront that it cannot be sustained.

RAW MATERIALS

Almost any raw material which is a good food or fuel can be used in a methane digester. The methane is generated by bacteria which are present in the air and in most rotting material. Cellulose will serve as a raw material for a methane digester and this is a valuable way to reduce cellulose. Cellulose is one of the toughest materials to break down into a usable fuel other than burning it in its solid state (trees, etc.). Humans and most other animals cannot digest cellulose and it is simply expelled unused in the feces. However sheep, cattle and other

"ruminants" (animals with even-toed hooves) can digest cellulose. They are not efficient at it, we might add, which is one reason why cow-chips burn so well. But these animals have a special digestive system with several stomachs. They regurgitate their food and chew their cud. They aren't just "dirty" eaters. This is all part of the digestive process. They expel a fair amount of methane gas also. But, at present, nobody has come up with a good idea of how to capture all of this waste methane from grazing cattle.

Absolutely staggering amounts of methane could be produced by municipal sewage disposals by the installation of methane digesters. Some progress has been made in this area. There are startup costs involved, of course, and there are training problems for operating personnel.

FATS

Cottonseed and soybeans both provide us with a fair amount of vegetable fats of high quality. Corn does too. There are a number of other vegetables that have a high fat content and there has been much development work directed at finding new such species and increasing the fat yield from the best producers. Fat has twice the energy value, pound for pound, of either proteins or carbohydrates. At present the best bulk fuel producers seem to be in the direction of those we have discussed previously. However vegetable and plant oils may be a very valuable source of lubricating and general purpose oils in the future.

SUMMARY OF RECENT REPLENISHIBLE FUEL DEVELOPMENTS

A continuous-flow process of converting cellulose to glucose has been developed by two professors at New York University. Professors Brenner and Rugg have developed a converted plastics extrusion machine into a process that converts one ton of old newspapers and sawdust per day into 1200 pounds of glucose. Glucose, of course, can then be directly fermented into Ethanol using procedures we are all

familiar with. The developers of this system believe they can cut the cost of manufacturing alcohol in half.

A scientist from GOODYEAR Tire and Rubber Co. states that it is feasible to produce tires from replenishable alcohols. It now takes seven gallons of oil to make an average tire. Five of these gallons are for raw material and two provide energy to run the plant.

During the second world war, the U.S. produced over 200,000 tons of butadiene (synthetic rubber) from alcohols. This was half our war-time needs. When petroleum became cheap after the war this was discontinued. The production of Natural Rubber is now very small compared to world needs. This could be changed if the price of other energy-related products continues to rise. 100 percent ethanol is not needed for rubber production. Any grade of ethanol is useable.

In the rubber area there is also a small shrub named GUAYULE that could be the complete answer. Rubber Industry officials are encouraging the government to show farmers how to grow and harvest Guayule. It has been under investigation as a rubber source for more than 50 years and one rubber company (Goodyear again) has no doubts about being able to use the rubber from Guayule if only farmers can learn to properly produce it.

MILKWEEDS are considered to be a great natural source of natural oils. Dr. Melvin Calvin of the University of California claims that growing oil-yielding plants makes better sense than fermenting relatively expensive grains to make ethanol.

Brazil is using 20 percent ethanol in its gasohol and claims are made that up to 40 percent can be used without major alterations to the vehicles. Also it is claimed that economical catalysts can be used in gasohol to allow the use of inferior grades of ethanol that have a higher water content.

Approximately 110 billion gallons of gasoline are consumed in the

United States each year. This is about 300 million gallons a day or 210,000 gallons a minute. If all of this gasoline was converted to 10 percent gasohol, it would require about 11 billion gallons of ethanol – enough to consume 60 percent of the U.S. Corn crop.

The U.S. typically produces over 50 million tons of wheat and more than 175 million tons of corn in good years (over 7 billion bushels of corn). Of this total corn and wheat crop, over 70 million tons are exported for cash and another smaller amount for International Food Relief programs (fee). In the near future the capacity to produce ethanol will be about 50 to 100 million gallons a year – only enough to consume about 25 million bushels of corn.

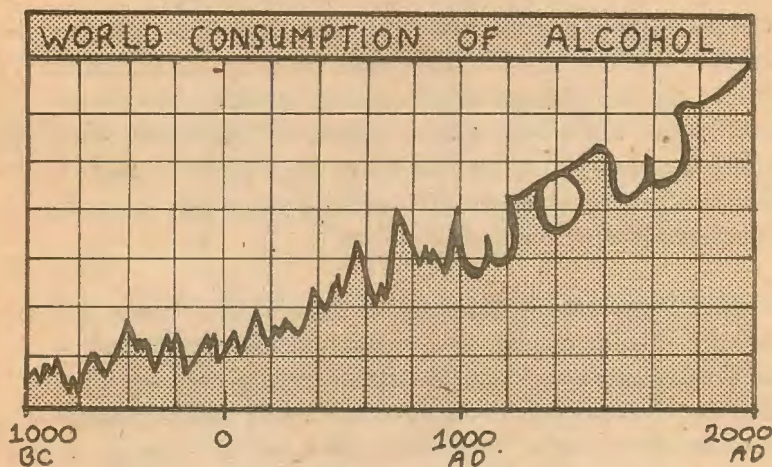
Phillips Petroleum, Standard Oil of Indiana, and Texaco are amongst a growing number of oil companies – large and small – merchandising gasohol. At the present time Ethanol costs more per gallon than does gasoline, so the blend necessarily sells for slightly more than gasoline alone. The 4 cent a gallon federal excise tax on gasoline is exempted on gasohol which helps some. A few states exempt gasohol from state taxes. The U.S. Energy Dept. estimates that by 1985 only one percent of the gasoline sold will be gasohol. If the new federal subsidy programs produce the results expected this projected figure might be 10 times as great so that 10 percent of the motor fuel sold in 1985 could be gasohol.

At the present time the nation's largest gasohol manufacturing plant is the anhydrous alcohol plant of the ARCHER, DANIELS AND MIDLAND CO. at Decatur, Illinois.

A gasohol plant design school is located in Kolby, Kansas.

CHAPTER 12

Charts, Tables & References



This chapter contains the charts and tables that are necessary to give the reader a complete reference text. They are gathered together in this final chapter to allow for easy referral. A brief explanation is included with those Tables that may not be self-explanatory.

ALCOHOLIC BEVERAGE GUIDE

A quick reference comparison between most common and many uncommon alcoholic drinks. (Starts on next page.)

ALCOHOLIC BEVERAGE GUIDE

NAME	GENERIC NAME	PERCENT ALCOHOL	PROOF (U.S.)	METHOD OF PRODUCTION	COMMENTS
ABSINTHE	Liqueur	68	136	Compounded	Mixture of aromatic plants and Brandy. Yellow-green, licorice flavored
AKVAVIT				Distilled at 190 Proof	From grain or potatoes, flavored with caraway seed and other herbs.
ALE	Beer	6	12	Fermented	Pale to dark; bittersweet
ALSATIAN WINE	Wine	14 or less	28 or less	Fermented	Rhinewine; dry white table wine
AMERICAN BRANDY	Brandy	42 to 54	84 to 108	Distilled at 140 Proof	From wine (fruit or grape) Light gold, Oak flavor
ANISETTE	Liqueur	27	54	Compounded	Flavored with aniseed; white
ANGOSTURA	Bitter	40 or less	80 or less	Compounded	Dark, bitter
APPLE JACK	Wine	14	28	Fermented	Light, dry
APRICOT LIQUEUR	Liqueur	30	60	Compounded	
ARMAGNAC BRANDY	Brandy	42 to 54	84 to 108	Distilled at 140 Proof	Brown, dry. Distilled from wine
AROMATIZED WINE	Wine	15 to 20	30 to 40	Brandy Added	
ARRACK PUNSCH	Liqueur	30	60	Compounded	Simple syrup, herbs and Batavia Arrack
BATAVIA ARRACK	Rum	43 to 79	86 to 158	Distilled at 160 Proof	Dry, brandy-like

ALCOHOLIC BEVERAGE GUIDE

NAME	GENERIC NAME	PERCENT ALCOHOL	PROOF (U.S.)	METHOD OF PRODUCTION	COMMENTS
BEER	Beer	1.2 to 16	2.4 to 32	Fermented	Fermented mash of malted grains, usually barley, with hops added for flavor.
BENEDICTINE	Liqueur	30	60	Compounded	Secret blend of herbs and spices. Spicy and sweet. Golden
BITTER	Bitter	40 or less	80 or less	Compounded	Neutral spirits redistilled with or flavored with various herbs and plants.
BLACKBERRY LIQUEUR	Liqueur	43	86	Compounded	Dark red; sweet
BLACKBERRY WINE	Wine	2 to 8	4 to 16	Fermented	
BLUEBERRY WINE	Wine	2 to 8	4 to 16	Fermented	
BOURBON	Whiskey	40 to 55	80 to 110	Distilled at 160 Proof	Made from no less than 51 percent corn grain
BURGUNDY	Wine	14 or less	28 or less	Fermented	Red or white. Dry table wine.
BRANDY	Brandy	42 to 54	84 to 108	Distilled at 140 Proof	From wine
CALVADOS	Brandy	"	"	"	From apple wine. Brown, dry
CANADIAN WHISKEY	Whiskey	40 to 55	80 to 110	Distilled at 160 Proof	From Rye grains. A blend of Canadian Rye whiskeys

ALCOHOLIC BEVERAGE GUIDE

NAME	GENERIC NAME	PERCENT ALCOHOL	PROOF (U.S.)	METHOD OF PRODUCTION	COMMENTS
CHAMPAGNE	Wine	14 or less	28 or less	Fermented	Sparkling. White or pink, table or dessert, dry or sweet
CHARTREUSE	Liqueur	43	86	Compounded	Yellow. Sweet, spicy, secret blend.
		55	11	Compounded	Green. Secret blend. Sweet, spicy.
CHIANTI	Wine	14 or less	28 or less	Fermented	Dry red table wine
CIDER	Wine	2 to 8	4 to 16	Fermented	From apples. Light colored, sweet.
CLARET	Wine	14 or less	28 less	Fermented	Red or white table wine
COGNAC	Brandy	42 to 54	84 to 108	Distilled at 140 Proof	From fruit wines. Brown, dry.
COINTREAU	Liqueur	40	80	Compounded	A brand oTriple Sec
CORDIAL	Liqueur				
CORDIAL MEDOC	Liqueur	30	60	Compounded	Blend of brandy, Curacao and Cacao
CREME DE ANANAS	Liqueur	30	60	Compounded	From Pineapple
CREME DE CACAO	Liqueur	30	60	Compounded	From Chocolate and Vanilla
CREME DE CAFE	Liqueur	30	60	Compounded	From Coffee
CREME DE CASSIS	Liqueur	18	36	Compounded	From red or black currants
CREME DE FRAISES	Liqueur	30	60	Compounded	From strawberries

ALCOHOLIC BEVERAGE GUIDE

NAME	GENERIC NAME	PERCENT ALCOHOL	PROOF (U.S.)	METHOD OF PRODUCTION	COMMENTS
CREME DE MENTHE	Liqueur	30	60	Compounded	from Peppermint
CREME DE NOYAUS	Liqueur	30	60	Compounded	From bitter almond
CUBAN RUM	Rum	43 to 79	86 to 158	Distilled at 160 Proof	Light or dark, sweet or dry
DEMERARA	Rum	43 to 79	86 to 158	Distilled at 160 Proof	Dark, sweet
DRAMBUIE	Liqueur	30	60	Compounded	Secret blend of Scotch whiskey and honey. Golden, spicy-sweet.
DUBONNET	Wine	15 to 20	30 to 40	Fermented Aromatized	Red, sweet appetizer.
FORBIDDEN FRUIT	Liqueur	30	60	Compounded	From Shaddock grapefruit and Brandy. Orange color, sweet.
FORTIFIED WINE	Wine	16 to 23	32 to 46	Fermented	Brandy added to increase alcohol content.
FRENCH VERMOUTH	Wine	15 to 20	30 to 40	Fermented Fortified	Dry white appetizer wine. Brandy added.
FRUIT GIN	Gin	43	86	Distilled at 190 Proof	From grains with fruit extracts.
GIN	Gin	43	86	Distilled at 190 Proof	From cereal grains, mostly corn. Sweetened or not, flavored with juniper berries, almonds cardomons, coriander or licorice. Not aged.

ALCOHOLIC BEVERAGE GUIDE

NAME	GENERIC NAME	PERCENT ALCOHOL	PROOF (U.S.)	METHOD OF PRODUCTION	COMMENTS
GREEK BRANDY	Brandy	42 to 54	84 to 108	Distilled at 140 Proof	From fruit juices. Dark, sweet, resinous flavor.
HOLLANDS	Gin	43	86	Distilled at 98 Proof	Dry, white.
ITALIAN VERMOUTH	Wine	15 to 20	30 to 40	Fermented Fortified	Brown colored. Appetizer, sweet or dry. Brandy added.
IRISH WHISKEY	Whiskey	40 to 55	80 to 110	Distilled at 160 Proof	Blend of Irish whiskeys. From barley, oats, wheat and rye.
JAMAICAN RUM	Rum	43 to 79	86 to 158	Distilled at 160 Proof	Gold colored, sweet.
KIRSCH	Brandy	42 to 54	84 to 108	Distilled at 140 Proof	From cherries.
KUMMEL	Liqueur	30 to 40	60 to 80	Compounded	Spiced with caraway and cumin seed.
LIQUEUR	Liqueur	18 to 55	36 to 110	Compounded	Various fruits steeped in brandy which then may or not be redistilled. Neutral spirits flavored and artificially colored.
LIQUEUR D'OR	Liqueur	43	86	Compounded	Flavored with lemon peel and herbs
MADEIRA	Wine	16 to 23	32 to 46	Fermented Fortified	Golden dessert. Sweet or dry. Brandy added.
MALAGA	Wine	16 to 23	32 to 46	Fermented Fortified	Dark red dessert. Sweet, Brandy added.

ALCOHOLIC BEVERAGE GUIDE

NAME	GENERIC NAME	PERCENT ALCOHOL	PROOF (U.S.)	METHOD OF PRODUCTION	COMMENTS
MALT WHISKEY	Whiskey	40 to 55	80 to 110	Distilled at 160 Proof	From not less than 51 percent malted Barley or Rye.
MARASCHINO	Liqueur	30	60	Compounded	Wild Cherry. White.
MARSALA	Wine	16 to 23	32 to 46	Fermented Fortified	Brown. Sweet dessert. Brandy added.
MONTILLA	Wine	15 to 20	30 to 40	Fermented Aromatized	Straw colored. Dry appetizer wine. Brandy added.
MOSELLE	Wine	14 or less	28 or less	Fermented	Dry white table wine.
MUSCATEL	Wine	16 to 23	32 to 46	Fermented Fortified	Golden sweet dessert wine. Brandy added.
NATURAL WINE	Wine	14 or less	28 or less	Fermented	Non-effervescent (still), or effervescent (sparkling).
OLD TOM	Gin	43	86	Distilled at 190 Proof	White. Medium sweet.
ORANGE BITTERS	Bitter	40 or less	80 or less	Compounded	Flavored with dried Seville orange peel.
PEACH LIQUEUR	Liqueur	30	60	Compounded	
PEACH WINE	Wine	2 to 8	4 to 16	Fermented	
PERRY	Wine	2 to 8	4 to 16	Fermented	Sparkling. From pear. Straw, sweet.

ALCOHOLIC BEVERAGE GUIDE

NAME	GENERIC NAME	PERCENT ALCOHOL	PROOF (U.S.)	METHOD OF PRODUCTION	COMMENTS
PORT	Wine	16 to 23	32 to 46	Fermented Fortified	Golden or red. Sweet dessert. Brandy added.
PORTER	Beer	6	12	Fermented	Dark, bitter. Like stout but not as strong.
PULQUE	Wine	2 to 8	8 to 16	Fermented	From Agave cactus. Resembles sour milk.
QUETSCH	Brandy	42 to 54	84 to 108	Distilled at 140 Proof	From Plum wine. White, dry.
QUINQUINA	Wine	15 to 20	30 to 40	Fermented Aromatized	Appetizer. Red or white; sweet or bitter. Brandy added.
RHONE	Wine	14 or less	28 or less	Fermented	Red or white. Dry table wine.
RIESLING	Wine	14 or less	28 or less	Fermented	Dry white table wine.
RUM	Rum	43 to 79	86 to 158	Distilled at 160 Proof	From fermented sugar cane molasses. Colored with caramel, flavored with cognac and fruit.
RYE WHISKEY	Whiskey	40 to 55	80 to 110	Distilled at 160 Proof	From not less than 51 percent rye grain.
SAKE	Wine or Beer	14 to 16	28 to 32	Fermented	From rice. White dry wine or beer.
SAUTERNES	Wine	14 or less	28 or less	Fermented	Sweet white dessert wine.

ALCOHOLIC BEVERAGE GUIDE

NAME	GENERIC NAME	PERCENT ALCOHOL	PROOF (U.S.)	METHOD OF PRODUCTION	COMMENTS
SCOTCH	Whiskey	40 to 55	80 to 110	Distilled at 160 Proof	Blend of straight Scottish whiskeys (made from peat-smoked malted barley).
SHERRY	Wine	16 to 23	32 to 46	Fermented Fortified	Amber appetizer. Sweet or dry. Brandy added.
SLIVOVITZ	Brandy	42 to 54	84 to 108	Distilled at 140 Proof	From Plum wine. Dry, brown.
SLOE GIN	Liqueur	18 to 55	36 to 110	Compounded	From wild plum. Red, sweet.
SPANISH BRANDY	Brandy	42 to 54	84 to 108	Distilled at 140 Proof	From Grape wine. Brown, medium dry.
SPARKLING ASTI SPUMANTE	Wine	14 or less	28 or less	Fermented	Sparkling. Sweet white table wine.
SPARKLING BURGUNDY	Wine	14 or less	28 less	Fermented	Sparkling. Red or white. Medium sweet table wine.
SPARKLING MOSELLE	Wine	14 or less	28 or less	Fermented	Sparkling. White sweet table wine.
SPARKLING WINES	(see natural wines)				
STILL WINES	(see natural wines)				
STOUT	Beer	6	12	Fermented	A dark ale. Strong malt flavor. Bitter.

ALCOHOLIC BEVERAGE GUIDE

NAME	GENERIC NAME	PERCENT ALCOHOL	PROOF (U.S.)	METHOD OF PRODUCTION	COMMENTS
STRAIGHT WHISKEY	Whiskey	40 to 55	80 to 110	Distilled at 160 Proof	From fermented grains and cereals, one of which makes up not less than 51 percent of the grain used this grain then gives it its name.
STRAWBERRY WINE	Wine	2 to 8	4 to 16	Fermented	
TEQUILA		40 to 55	80 to 110	Distilled	From the juice of the Tequila century plant.
TOKAY	Wine	16 to 23	32 to 46	Fermented Fortified	Sweet dessert wine. Red. Brandy added.
TRIPLE SEC	Liqueur	40	80	Compounded	A white, sweet curacao.
VANDER HUM	Liqueur	35	70	Compounded	From tangerines (mandarines).
VODKA	Vodka	45 to 57	90 to 115	Distilled at 150 Proof	From a mash of wheat and a little malt. Not flavored or aged. White, dry.
WHEAT WHISKEY	Whiskey	40 to 55	80 to 110	Distilled 160 Proof	From not less than 51 percent wheat grain.
WHISKEY	Whiskey	40 to 55	80 to 110	Distilled at 160 Proof	From various cereal grains - can be either straight or blended.
WHISKEY BLENDS	Whiskey	40 to 55	80 to 110	Distilled at 160 Proof	Any straight whiskey blended with a neutral spirit, or with another straight whiskey.

ALCOHOLIC BEVERAGE GUIDE

NAME	GENERIC NAME	PERCENT ALCOHOL	PROOF (U.S.)	METHOD OF PRODUCTION	COMMENTS
WINE	Wine	2 to 23	4 to 46	Fermented	Fermented fruits or vegetables, usually grape. Can be natural (still), sparkling, fortified, or aromatized.
ZUBROVKA	Vodka	45 to 57	90 to 115	Distilled at 150 Proof	Vodka flavored with zubroyka grass -- slightly bitter. Dry.

TABLE B

WEIGHTS & MEASURES

U.S. LIQUID MEASURE

	No. gals.	No. qts.	No. pts.	No. cups	No. oz.	No. T.	No. tsp.	No. gr.	No. lb.
GALLON	1	4	8	16	128	256	768	3789	8
QUART	$\frac{1}{4}$	1	2	4	32	64	192	947.2	2
PINT	$\frac{1}{8}$	$\frac{1}{2}$	1	2	16	32	96	473.6	1
CUP	$\frac{1}{16}$	$\frac{1}{4}$	$\frac{1}{2}$	1	8	16	48	240	$\frac{1}{2}$
OUNCE	$\frac{1}{128}$	$\frac{1}{32}$	$\frac{1}{16}$	$\frac{1}{8}$	1	2	6	29.6	$\frac{1}{16}$
TABLESPOON	$\frac{1}{256}$	$\frac{1}{64}$	$\frac{1}{32}$	$\frac{1}{16}$	$\frac{1}{2}$	1	3	15	$\frac{1}{32}$
TEASPOON	$\frac{1}{768}$	$\frac{1}{192}$	$\frac{1}{96}$	$\frac{1}{48}$	$\frac{1}{6}$	$\frac{1}{3}$	1	5	$\frac{1}{96}$
GRAMS	XXXX	$\frac{1}{947}$	$\frac{1}{473}$	$\frac{1}{240}$	$\frac{1}{29}$	$\frac{1}{15}$	$\frac{1}{5}$	1	$\frac{1}{473}$
POUND	$\frac{1}{8}$	$\frac{1}{2}$	1	2	16	32	96	473.6	1

Dash = less than 1/8 teaspoon.

AVOIRDUPOIS - COMMERCIAL

1 pound (lb. av.) = 16 oz. = 256 drams = 7000 grains

1 ounce (oz. av.) = 16 drams = 437.5 grains

1 dram (dr. av.) = 27.344 grains

METRIC EQUIVALENT

1 pound = 453.592 grams

1 ounce = 28.3495 grams

1 dram = 1.7718 grams

1 grain = 0.0648 gram

1 gallon = 3.785 liters = 3785 cubic centimeters

1 quart = 0.946 liter = 946 cubic centimeters

1 pint = 0.473 liter = 473 cubic centimeters

1 fluid ounce = 0.0295 liter = 29.5 cubic centimeters

MISC.

1 BTU = 252 calories

1 Acre = 43,560 square feet

640 acres = one square mile

1 cubic foot = 7.48 gallons

1 gallon = 231 cubic inches = .1336 cubic feet

1 gallon water = 8 1/3 lbs.

TABLE C
PROOF TABLES FOR ALCOHOL

This table gives the relationship existing between the various types of proof in existence in Great Britain, Canada and the U.S. All of the various types are referenced to percent alcohol by volume. Note that both the Canadians and British use the same scale (Sykes) but the Canadians use 100 proof as their reference point. Anything under this is Under proof and anything over is Over proof. The negative signs indicate Under and the positive signs Over.

% ALCOHOL by volume	PROOF SCALES		
	U.S.A.	British or Sykes	Canadian*
2	4	3.5	-96.5
4	8	7.0	-93.0
6	12	10.5	-89.5
8	16	14.0	-86.0
10	20	17.5	-82.5
12	24	21.0	-79.0
14	28	24.5	-75.5
16	32	28.0	-72.0
18	36	31.5	-68.5
20	40	35.0	-65.0
25	50	43.8	-56.2
30	60	52.5	-47.5
35	70	61.3	-38.7
40	80	70.0	-30.0
45	90	78.8	-21.2
50	100	87.5	-12.5
60	120	105.0	+ 5.0
70	140	122.5	+22.5
80	160	140.0	+40.0
100	200	175.0	+75.0

TABLE D**ALCOHOL CONVERSION TABLE**

This table correlates percent by volume to percent by weight and vice-versa. For instance a 12 percent wine (alcohol by volume) would be equivalent to 9.679 by weight.

This table takes into account the shrinkage that results from mixing alcohol with water.

PERCENTAGE BY VOLUME				PERCENTAGE BY WEIGHT			
Percent Vol.	Corresponding Percent Wt.	Percent Vol.	Corresponding Percent Wt.	Percent Wt.	Corresponding Percent Vol.	Percent Wt.	Corresponding Percent Vol.
*0	*0.000	51	43.428	*0	*0.000	51	58.844
1	0.795	52	44.374	1	1.257	52	59.851
2	1.593	53	45.326	2	2.510	53	60.854
3	2.392	54	46.283	3	3.758	54	61.850
4	3.194	55	47.245	4	5.002	55	62.837
5	3.998	56	48.214	5	6.243	56	63.820
6	4.804	57	49.187	6	7.479	57	64.798
7	5.612	58	50.167	7	8.712	58	65.768
8	6.422	59	51.154	8	9.943	59	66.732
9	7.234	60	52.147	9	11.169	60	67.690
10	8.047			10	12.393		
11	8.862	61	53.146	11	13.613	61	68.641
12	9.679	62	54.152	12	14.832	62	69.586
13	10.497	63	55.165	13	16.047	63	70.523
14	11.317	64	56.184	14	17.259	64	71.455
15	12.138	65	57.208	15	18.469	65	72.380
16	12.961	66	58.241	16	19.676	66	73.299
17	13.786	67	59.279	17	20.880	67	74.211
18	14.612	68	60.325	18	22.081	68	75.117
19	15.440	69	61.379	19	23.278	69	76.016
20	16.269	70	62.441	20	24.472	70	76.909
21	17.100	71	63.511	21	25.662	71	77.794
22	17.933	72	64.588	22	26.849	72	78.672
23	18.768	73	65.674	23	28.032	73	79.544
24	19.604	74	66.768	24	29.210	74	80.410
25	20.443	75	67.870	25	30.388	75	81.269
26	21.285	76	68.982	26	31.555	76	82.121
27	22.127	77	70.102	27	32.719	77	82.967
28	22.973	78	71.234	28	33.879	78	83.805
29	23.820	79	72.375	29	35.033	79	84.636
30	24.670	80	73.526	30	36.181	80	85.459
31	25.524	81	74.686	31	37.323	81	86.275
32	26.382	82	75.858	32	38.459	82	87.083
33	27.242	83	77.039	33	39.590	83	87.885
34	28.104	84	78.233	34	40.716	84	88.678
35	28.971	85	79.441	35	41.832	85	89.464
36	29.842	86	80.662	36	42.944	86	90.240
37	30.717	87	81.897	37	44.050	87	91.008
38	31.596	88	83.144	38	45.149	88	91.766
39	32.478	89	84.408	39	46.242	89	92.517
40	33.364	90	85.689	40	47.328	90	93.254
41	34.254	91	86.989	41	48.407	91	93.982
42	35.150	92	88.310	42	49.480	92	94.700
43	36.050	93	89.652	43	50.545	93	95.407
44	36.955	94	91.025	44	51.605	94	96.103
45	37.865	95	92.423	45	52.658	95	96.787
46	38.778	96	93.851	46	53.705	96	97.457
47	39.697	97	95.315	47	54.746	97	98.117
48	40.622	98	96.820	48	55.780	98	98.759
49	41.551	99	98.381	49	56.808	99	99.386
50	42.487	100	100.000	50	57.830	100	100.000

TABLE E**TEMPERATURE CONVERSION TABLE**

This table converts Centigrade degrees to Fahrenheit degrees as this is the usual direction in which you will want to convert. If you can manipulate formulas, the conversion is

$$F^{\circ} = 1.8 \times C^{\circ} + 32$$

$$C^{\circ} = 5/9 \times (F^{\circ} - 32)$$

DEGREES CENTIGRADE TO FAHRENHEIT

°C.	°F.	°C.	°F.	°C.	°F.	°C.	°F.	°C.	°F.	°C.	°F.	°C.	°F.
-50	-58.0	5	23.0	40	104.0	85	185.0	130	266.0	175	347.0	220	428.0
49	56.2	4	24.8	41	105.8	86	186.8	131	267.8	176	348.8	221	429.8
48	54.4	3	26.6	42	107.6	87	188.6	132	269.6	177	350.6	222	431.6
47	52.6	2	28.4	43	109.4	88	190.4	133	271.4	178	352.4	223	433.4
46	50.8	-1	30.2	44	111.2	89	192.2	134	273.2	179	354.2	224	435.2
45	49.0	0	32.0	45	113.0	90	194.0	135	275.0	180	356.0	225	437.0
44	47.2	+1	33.8	46	114.8	91	195.8	136	276.8	181	357.8	226	438.8
43	45.4	2	35.6	47	116.6	92	197.6	137	278.6	182	359.6	227	440.6
42	43.6	3	37.4	48	118.4	93	199.4	138	280.4	183	361.4	228	442.4
41	41.8	4	39.2	49	120.2	94	201.2	139	282.2	184	363.2	229	444.2
40	40.0	5	41.0	50	122.0	95	203.0	140	284.0	185	365.0	230	446.0
39	38.2	6	42.8	51	123.8	96	204.8	141	285.8	186	366.8	231	447.8
38	36.4	7	44.6	52	125.6	97	206.6	142	287.6	187	368.6	232	449.6
37	34.6	8	46.4	53	127.4	98	208.4	143	289.4	188	370.4	233	451.4
36	32.8	9	48.2	54	129.2	99	210.2	144	291.2	189	372.2	234	453.2
35	31.0	10	50.0	55	131.0	100	212.0	145	293.0	190	374.0	235	455.0
34	29.2	11	51.8	56	132.8	101	213.8	146	294.8	191	375.8	236	456.8
33	27.4	12	53.6	57	134.6	102	215.6	147	296.6	192	377.6	237	458.6
32	25.6	13	55.4	58	136.4	103	217.4	148	298.4	193	379.4	238	460.4
31	23.8	14	57.2	59	138.2	104	219.2	149	300.2	194	381.2	239	462.2
30	22.0	15	59.0	60	140.0	105	221.0	150	302.0	195	383.0	240	464.0
29	20.2	16	60.8	61	141.8	106	222.8	151	303.8	196	384.8	241	465.8
28	18.4	17	62.6	62	143.6	107	224.6	152	305.6	197	386.6	242	467.6
27	16.6	18	64.4	63	145.4	108	226.4	153	307.4	198	388.4	243	469.4
26	14.8	19	66.2	64	147.2	109	228.2	154	309.2	199	390.2	244	471.2
25	13.0	20	68.0	65	149.0	110	230.0	155	311.0	200	392.0	245	473.0
24	11.2	21	69.8	66	150.8	111	231.8	156	312.8	201	393.8	246	474.8
23	9.4	22	71.6	67	152.6	112	233.6	157	314.6	202	395.6	247	476.6
22	7.6	23	73.4	68	154.4	113	235.4	158	316.4	203	397.4	248	478.4
21	5.8	24	75.2	69	156.2	114	237.2	159	318.2	204	399.2	249	480.2
20	4.0	25	77.0	70	158.0	115	239.0	160	320.0	205	401.0	250	482.0
19	2.2	26	78.8	71	159.8	116	240.8	161	321.8	206	402.8	251	483.8
18	-0.4	27	80.6	72	161.6	117	242.6	162	323.6	207	404.6	252	485.6
17	+1.4	28	82.4	73	163.4	118	244.4	163	325.4	208	406.4	253	487.4
16	3.2	29	84.2	74	165.2	119	246.2	164	327.2	209	408.2	254	489.2
15	5.0	30	86.0	75	167.0	120	248.0	165	329.0	210	410.0	255	491.0
14	6.8	31	87.8	76	168.8	121	249.8	166	330.8	211	411.8	256	492.8
13	8.6	32	89.6	77	170.6	122	251.6	167	332.6	212	413.6	257	494.6
12	10.4	33	91.4	78	172.4	123	253.4	168	334.4	213	415.4	258	496.4
11	12.2	34	93.2	79	174.2	124	255.2	169	336.2	214	417.2	259	498.2
10	14.0	35	95.0	80	176.0	125	257.0	170	338.0	215	419.0	260	500.0
9	15.8	36	96.8	81	177.8	126	258.8	171	339.8	216	420.8	261	501.8
8	17.6	37	98.6	82	179.6	127	260.6	172	341.6	217	422.6	262	503.6
7	19.4	38	100.4	83	181.4	128	262.4	173	343.4	218	424.4	263	505.4
6	21.2	39	102.2	84	183.2	129	264.2	174	345.2	219	426.2	264	507.2

TABLE F**ALCOHOL DILUTION TABLE**

This is a handy table for mixing your own liquors to a desired strength. For instance, if you have 190 proof alcohol, and wish to cut it down to a 90 proof vodka, then use the 190 column under **Proof Of Uncut Liquor** heading. Go down this column until you arrive at your **Desired Proof** reading of 90 proof. The column entry at that point reads 118.0. This is the number of units of water (by volume) that you will need to add to 100 units of your uncut 190 proof to obtain the desired 90 proof vodka.

DESIRED PROOF	PROOF OF UNCUT LIQUOR											
	190%	188	184	180	170	160	150	140	130	120	110	100
180	6.4	5.1	2.5									
170	13.3	11.9	9.2	6.58								
160	20.9	19.5	16.6	13.8	6.83							
150	29.5	27.9	24.9	21.9	14.5	7.2						
140	39.1	37.5	35.9	34.2	23.1	15.3	7.64					
130	50.2	48.4	45.0	41.5	33.0	24.6	16.4	8.15				
120	63.0	61.2	57.3	53.6	44.2	35.4	26.5	17.6	8.76			
110	78.0	76.0	71.9	67.8	57.9	48.0	38.3	28.6	19.0	9.5		
100	95.9	93.6	89.2	84.8	73.9	63.1	52.4	41.7	31.3	20.5	10.4	
90	118.0	115.0	110.0	105.0	93.3	81.3	64.5	57.8	48.0	34.5	22.9	11.4
80	144.0	142.0	136.0	131.0	117.0	104.0	90.8	77.6	64.5	51.4	38.5	25.6
70	179.0	176.0	169.0	163.0	148.0	133.0	118.0	103.0	88.0	72.0	56.3	43.6
60	224.0	221.0	213.0	206.0	189.0	171.0	154.0	136.0	119.0	102.0	85.0	67.5
50	287.0	283.0	275.0	266.0	245.0	224.0	204.0	183.0	162.0	142.0	121.0	101.0
40	382.0	377.0	366.0	356.0	330.0	304.0	277.0	253.0	227.0	200.0	176.0	150.0
30	540.0	533.0	519.0	505.0	471.0	437.0	403.0	369.0	335.0	300.0	267.0	234.0

REFERENCE A**DIRECTOR & REGIONAL DIRECTORS AND REGIONS COVERED
for the Bureau of Alcohol Tobacco & Firearms (BATF)****DIRECTOR****OFFICE OF THE DIRECTOR**

Bureau of Alcohol, Tobacco and Firearms
1200 Pennsylvania Ave. N.W., Rm. 4000
Washington, DC 20226

NORTH ATLANTIC: (Connecticut, Maine, Massachusetts, New Hampshire, New York, Puerto Rico, Rhode Island, Vermont, Virgin Islands)

REGIONAL DIRECTOR

P.O. Box 15, Church St. Station
New York, NY 10008

MID ATLANTIC: (Delaware, DC, Maryland, New Jersey, Pennsylvania, Virginia)

REGIONAL DIRECTOR

2 Penn Center Plaza, Rm. 360
Philadelphia, PA 19102

SOUTHEAST: (Alabama, Florida, Georgia, Mississippi, North Carolina, South Carolina, Tennessee)

REGIONAL DIRECTOR

P.O. Box 2994
Atlanta, GA 30301

CENTRAL: (Indiana, Kentucky, Michigan, Ohio, W. Virginia)

REGIONAL DIRECTOR

550 Main St.
Cincinnati, OH 45202

MIDWEST: (Illinois, Iowa, Kansas, Minnesota, Missouri, Nebraska, N. Dakota, S. Dakota, Wisconsin)

REGIONAL DIRECTOR

230 S. Dearborn St., 15th Floor
Chicago, IL 60604

WEST: (Alaska, Arizona, California, Hawaii, Idaho, Montana, Nevada, Oregon, Utah, Washington)

REGIONAL DIRECTOR

525 Market St., 34th Floor
San Francisco, CA 94105

SOUTHWEST: (Arkansas, Colorado, Louisiana, New Mexico, Oklahoma, Texas, Wyoming)

REGIONAL DIRECTOR

Main Tower, Rm. 345
1200 Main St.
Dallas, TX 75202

REFERENCE B**SAMPLE LETTER TO THE BATF REQUESTING A STILL PERMIT**

Address your letter to the Regional Director (see Reference A) and then in large capital letters under this title put "GASOHOL" and then the rest of the address. Or you can address it to the Regional Regulatory Administrator. In any event, so long as you send it to the right address they will be able to sort it out to the right department when they receive it.

Date _____

Sirs,

I wish to obtain an experimental permit to produce Methanol for fuel. I intend to use carbohydrates of all types to ferment and will initially use conventional distilling techniques. After acquiring experience I hope to develop my own superior design(s).

I understand I am to keep a complete record of my production and its ultimate use. I will purchase a bond or post a cash bond to cover the taxes on 15 days production. This bond will be in the amount of \$21.00 per gallon of 100 percent Ethanol. I will comply with all laws including environmental and pollution statutes. I will not sell or drink any of the Ethanol and I will add at least 10 percent denaturants (poisons) to the Ethanol so produced. I am enclosing a legal description of my premises and my initial equipment plans.

Sincerely yours,

(be sure to include your full address and phone number somewhere on the letter).

REFERENCE C

WANT MORE INFORMATION??

There are a number of Government agencies and private groups that are more than willing to share with you their experience with GASOHOL and Ethanol fermentation and distillation. Some of these are given below. Because of the changing nature of many of the suppliers and organizations, we cannot list all of the many people and organizations involved. However if you will send a SASE (Self Addressed, Stamped Envelope) to Popular Topics Press, Box 1004, Fostoria, Ohio 44830, we will send you free of charge our latest printed listing. Please send a full sized business envelope (Nr. 10).

FARM ORGANIZATIONS

American Farm Bureau Federation
225 Touhy Ave.
Park Ridge, IL 60068

Agriculture Council of America
1625 Eye St. NW, Suite 708
Washington, DC 20006

National Corn Growers Assn.
815 Office Park Rd., Ste. 201
West Des Moines, IA 50265

National Farmers Organization
720 Davis Ave.
Corning, IA 50841

National Farmers Union
12025 E. 45th Ave.
Denver, CO 80251

UNIVERSITIES

Send to the STATE AGRICULTURAL COLLEGE for your state. This will usually be the University that has the designation STATE in its name. For instance in Ohio there are both an Ohio University (in Athens, Ohio) and an Ohio STATE University in Columbus, Ohio. In Oklahoma there is an Oklahoma University in Norman, Oklahoma, and an Oklahoma STATE University in Stillwater, Oklahoma. In both cases the university with STATE in its name is the agricultural university (land grant colleges.) Address your letter as follows:

College of Agriculture

GASOHOL

_____State University

city.....state.....zip

If you do not know the location of your state university, look in the back of any MERRIAM WEBSTERS NEW COLLEGIATE DICTIONARY. There is a section entitled Colleges & Universities that will give you the name and the city and state. This is an excellent source.

GOVERNMENT AGENCIES**USDA**

Secretary of Agriculture

14th St. & Independence Ave. SW

Washington, DC 20250

USDA

Farmers Home Administration

14th St. & Independence Ave. SW

Washington, DC 20250

Office of Energy

Office of the Secretary

U.S. Department of Agriculture

Washington, DC 20250

Ministry of Agriculture & Food

222 McIntyre St. W.

North Bay, Ontario, Canada P1B 2Y8

Write to the AGRICULTURE department of your state at the state capitol. The following address should get your letter to the correct office:

(your state) DEPARTMENT OF AGRICULTURE
GASOHOL
City.....State.....Zip

(example: Ohio Dept. of Agriculture)

OTHER ORGANIZATIONS AND SUPPLIERS

Micro Tec Laboratories
Rt. 2, Box 19
Logan, IA 51546

Rutan Publishing
P.O. Box 3585
Minneapolis, MN 55403

Home Wine & Beer Trade Assoc.
c/o Beverage Communicator
P.O. Box 43
Hartsdale, NY 10530

Miles Laboratories
Elkhart, IN 46514

Popular Topics Press
P.O. Box 1004
Fostoria, OH 44830

National Gasohol Commission
521 S. 14th St., Ste. 5
Lincoln, NE 68508

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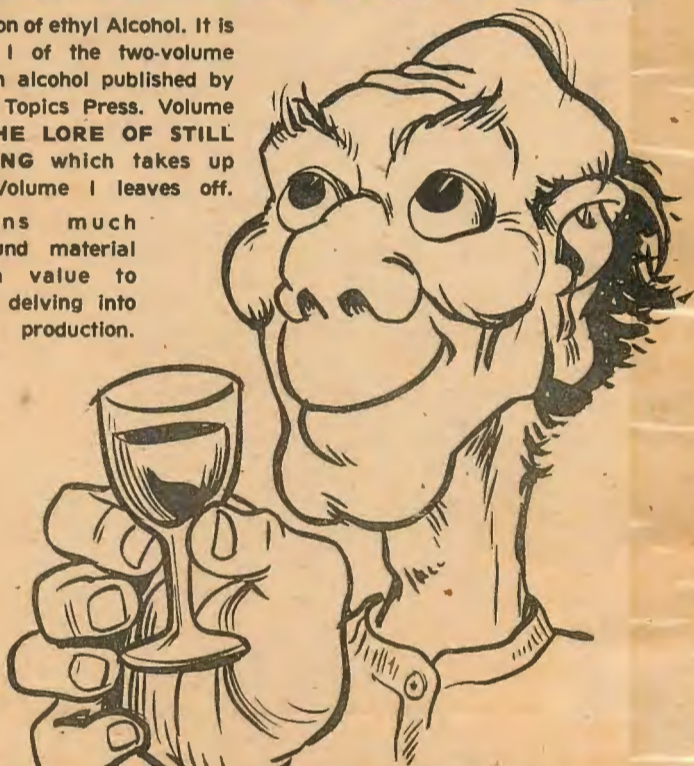
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lore, n. [AS. *lār.*] **1. Archaic.** Act of teaching, or that which is taught; hence, instruction; wisdom; counsel. **2.** Knowledge; learning; often, the whole body of knowledge possessed by a people or class, or pertaining to a particular subject, esp. when such knowledge is regarded as of a traditional description.

If we included the "whole body of knowledge" on the subject of stills and distillation it would take at least a 50 volume set! You wouldn't read it and we couldn't afford to publish it. On the other hand you can carry this book in your shirt pocket and when you finish reading it you'll know everything you wanted to know—and probably more! Consider it a 50 volume condensation.

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THE AUTHORS, IN HAPPIER DAYS (BEFORE THEIR STILL BLEW UP).